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THE COMPOSITE REPORT BAY AREA RAPID TRANSIT MAY 1962

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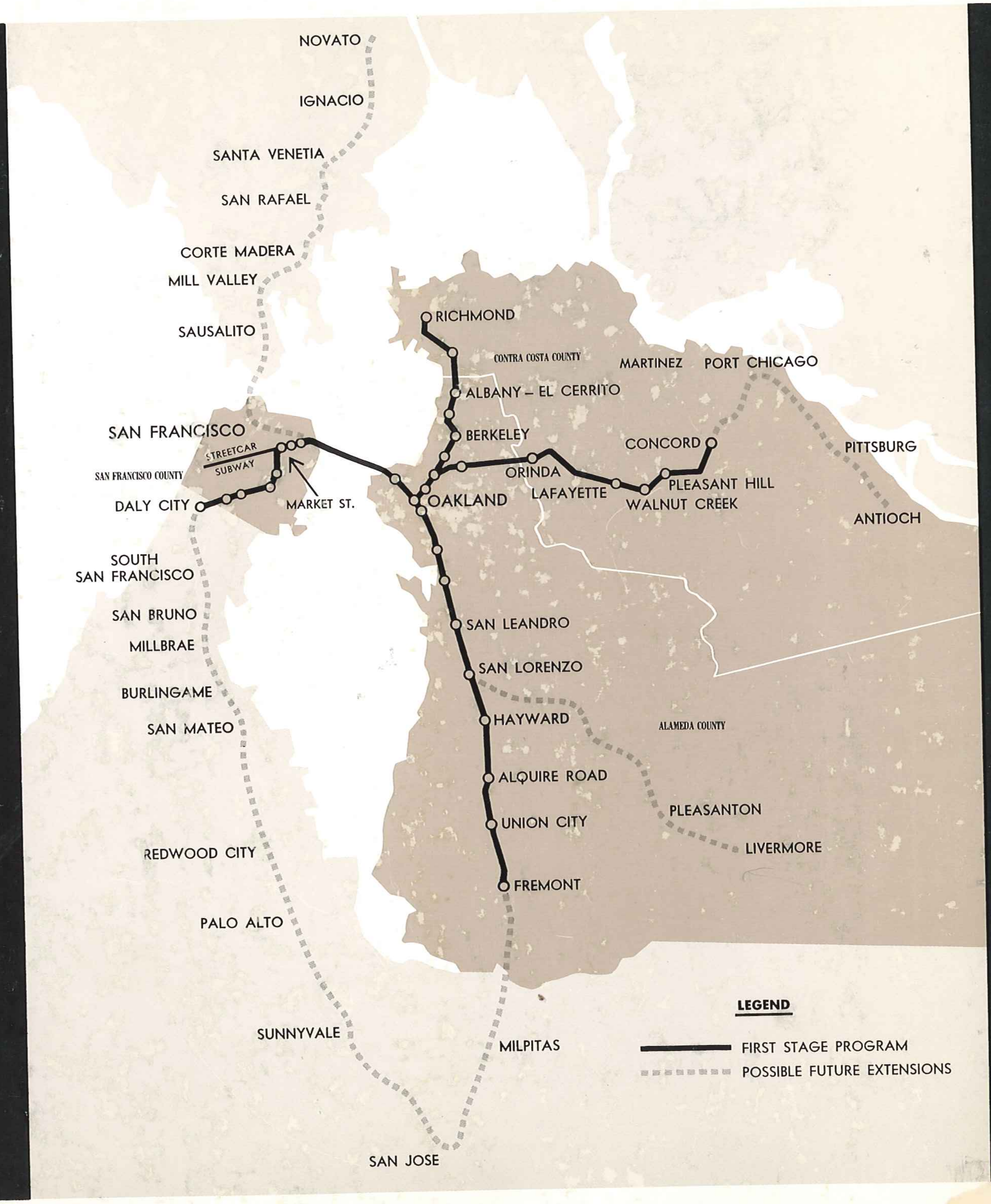
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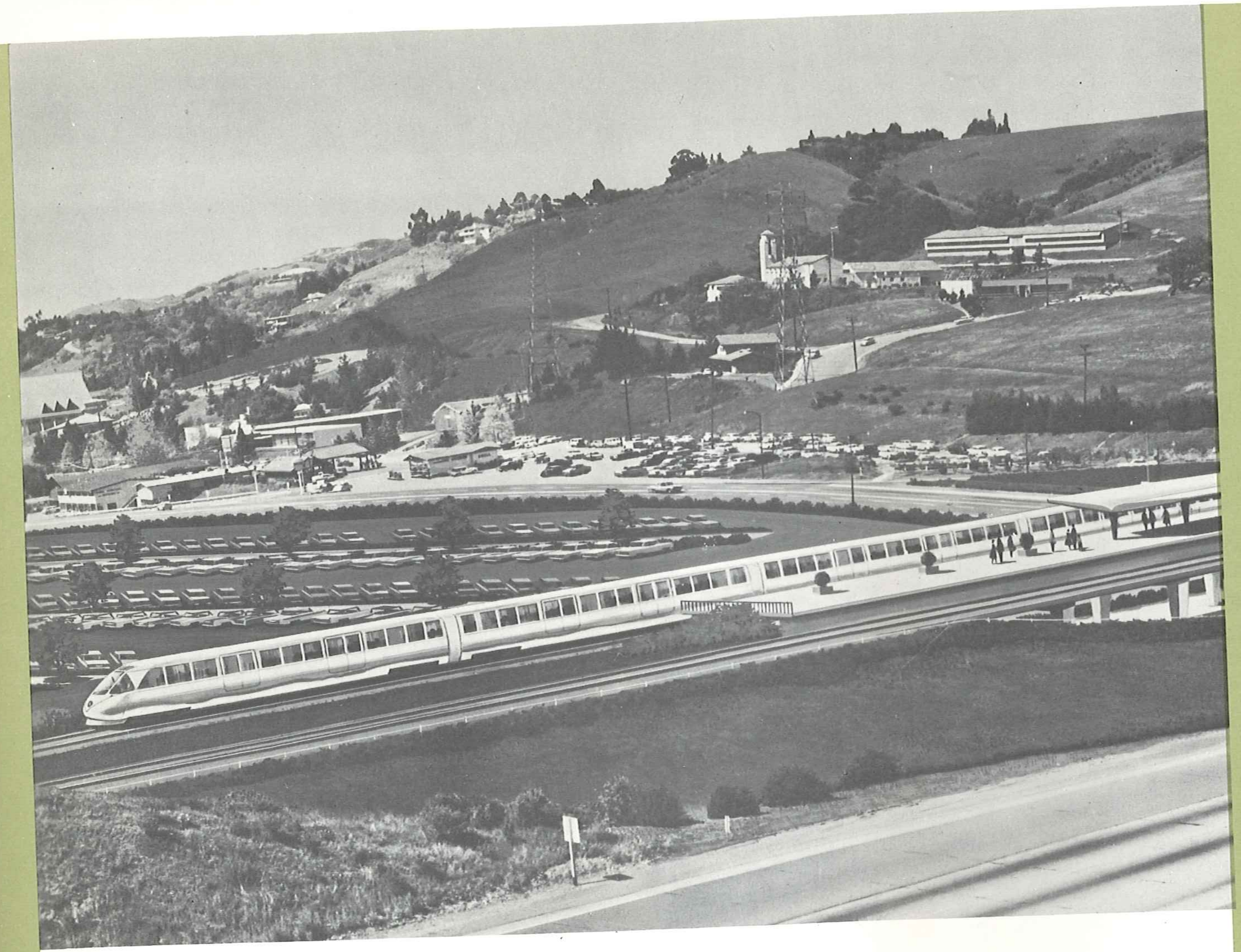
LEGEND
FIRST STAGE PROGRAM
POSSIBLE FUTURE EXTENSIONS



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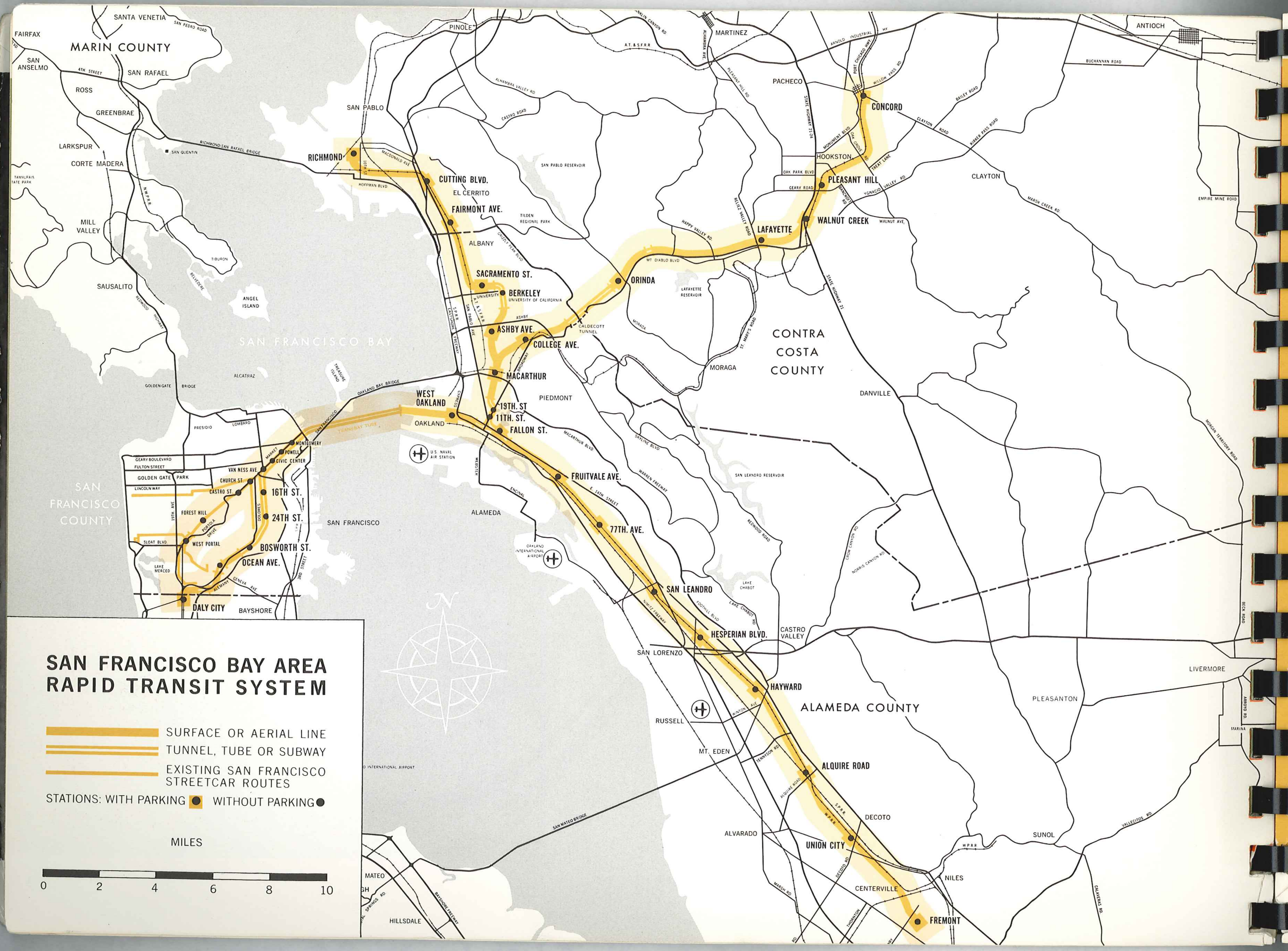

SAN FRANCISCO BAY AREA
RAPID TRANSIT SYSTEM

BASIC CONCEPTS AND STANDAI

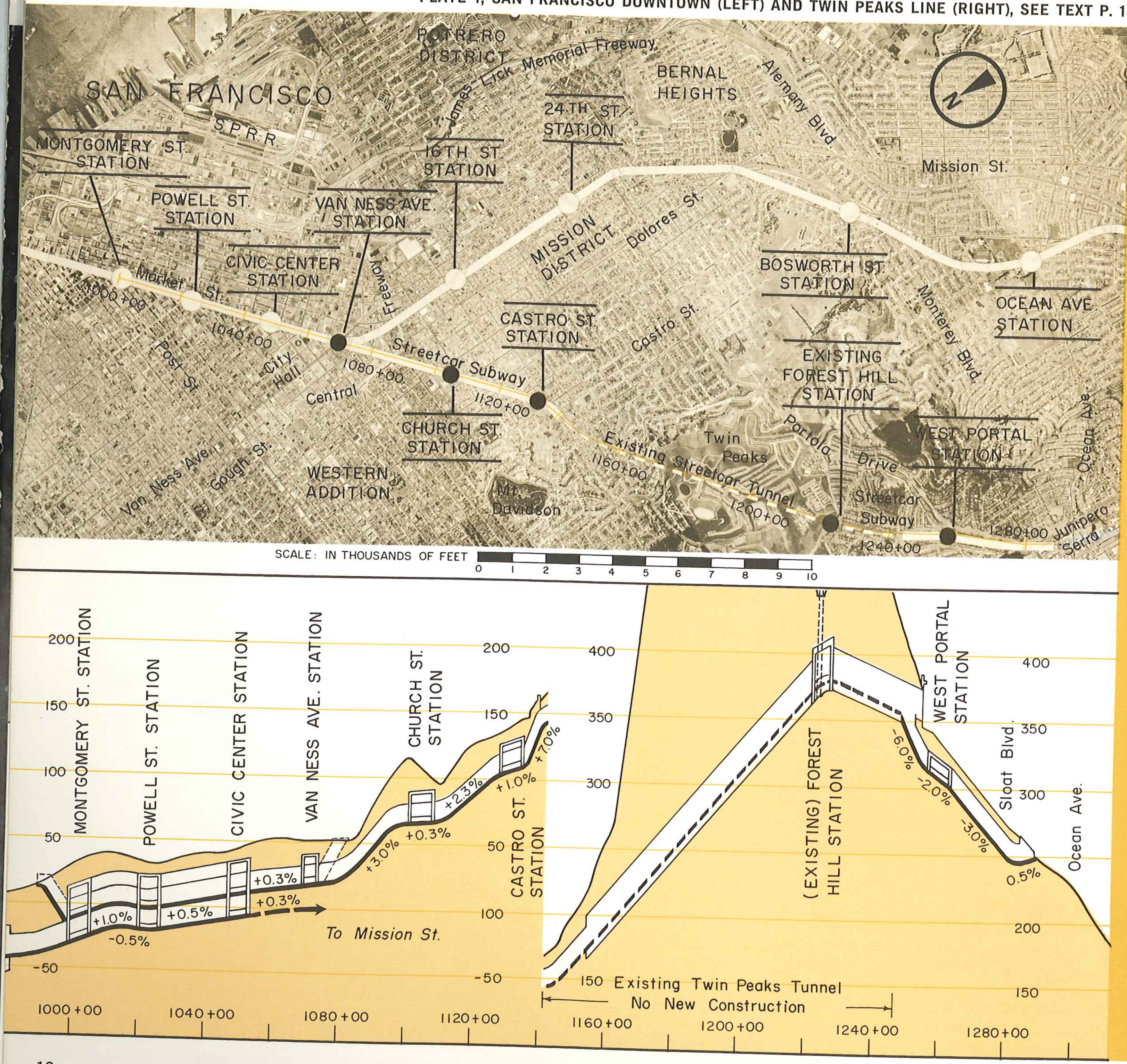
The regional rapid transit system will form an ir
tant and integral part of the total transportation f
ties of the San Francisco Bay Area. The networ
freeways, local streets, and local transit routes a
essential elements. By themselves, however, they
not carry the entire mounting burden of traffic,
ticularly in periods of peak demand. Together,
networks and the rapid transit system mutually
plement each other and afford the Bay Area the
prospect for a balanced and economical combin
of circulation facilities.

The Bay Area rapid transit system will abate n
vehicle congestion on the regional highways and i
urban centers, will encourage a continued high
and type of economic development, and will pre
and enhance a high living standard. Rapid trans
conceived in this system, will complement the pr
automobile as a mode of travel. At the same tin
must compete with the automobile. The relative at
tion of rapid transit and the automobile, together
important considerations of public acceptability,
major factors in establishing standards for rapid tr
methods, equipment, and operation.

Some of the salient standards established for
Bay Area rapid transit system are the following:

- Regional rapid transit must be capable of mini
  average operating speeds of about 45 miles
  hour, including station stops. To achieve this
  equipment must be capable of speeds of at lea
  miles per hour between stations and will in
  achieve average speeds of approximately 50 r
  per hour generally throughout the system.
- Service during periods of peak travel should be
  erned by demand, with headways as short a
  seconds to provide a capacity of at least 30
  seated passengers per hour. Off-peak period ser
  except late at night, should be as frequent as e
  15 minutes.
- The system must be safe and dependable.
- The rapid transit car must be comfortable,
  smooth riding qualities, internal temperature
  trol, adequate ventilation, cooling and heat
  sealed windows, freedom from fumes, a low ir
  nal noise level, and a pleasing interior and exte
  appearance.
- The regional system must penetrate the major
  ters of business and commerce close to the ultir
  destination of travelers to those centers.
- The equipment must have a low external noise

PLATE 1, SAN FRANCISCO DOWNTOWN (LEFT) AND TWIN PEAKS LINE (RIGHT), SEE TEXT P. 18



supported on steel wheels running on continuous steel rails and operated by automatic train control.

The adoption of this transportation method as a basis for the estimates in this report does not foreclose continuing analysis and possibly ultimate selection of any different or untraditional method. In considering the potential advantages and disadvantages of other methods of rapid transit, comparison can be made with this modern proven system. Any other transit method to be adopted should serve as well or better, and should be of equal or less cost.

The prototype car is 67 feet, 3 inches long; 10 feet, 5 inches wide; and seats 76 passengers. The unloaded weight of the car is under 800 pounds per seat. To achieve the required rates of acceleration each car is self-propelled. Power is supplied by third rail to electric motors driving each of the four axles. Doors are of the sliding type, and the windows are permanently sealed. The interior as well as exterior appearance of the rapid transit car is attractive. Suitable ventilation and cooling and heating, freedom from fumes, and a low noise level are necessary for passenger comfort and satisfaction. Smooth riding qualities are essential.

In addition the vehicle is safe to passengers and employees, and requires the minimum outlay for capital costs of way and equipment and for costs of operating and maintaining the system.

POWER AND PROPULSION

Numerous methods of propulsion and power supply have been studied and evaluated in correlation with the studies of various transit methods. Power supply for a rapid transit system is usually direct-current electrical energy purchased as alternating current and then rectified to direct current. Operation of trains in subways and long tunnels precludes the use of gasoline or diesel powered equipment producing noxious fumes. While some potential does exist for new energy sources in the long-range future, the use of bulk-generated electric energy is still the most practical, efficient, and economical method for today's application.

Three main types of electric motors have characteristics more or less suited to traction applications. The polyphase induction motor is an extremely rugged, low-maintenance, and low-cost motor with the significant advantage that three-phase alternating current could be utilized directly without the necessity of providing rectifying equipment to convert the energy to direct current. This motor, however, is essentially a constant-speed machine, requiring additional transmission devices which introduce complicatio
offset the advantages of the motor. Also, the p
of transferring polyphase energy from the track
the moving car has not yet been solved satisfa

The single-phase series motor has been used i
motives but it is being replaced by lighter, mo
cient propulsion equipment. It does not offer a
vantage for the proposed system.

The direct-current series motor is the most
used for transit purposes. Its design has been
oped to a high degree of refinement and tod
motor is comparatively light, rugged, compa
efficient, requiring a minimum of maintenance.
native propulsion methods proposed so far hav
limitations in performance, current collection,
and weight that the direct-current series motor
logical choice now as a basis for estimating cost
does not preclude ultimate adoption of a supe
ternative should one become available prior
time when final selection must be made.

Direct-current equipment normally is avail
three voltage ranges – 750 volts, 1500 volts, an
volts. However, the design of equipment for
system voltages up to 750 volts is the most hig
veloped. Such equipment is light and compact, a
required control equipment is reliable and low i
Dynamic braking is feasible without compli
Consequently, the lower-voltage equipment ha
chosen as the basis of design and estimate.

The proposed method of supplying power to
from the trackside is a third-rail system. The sys
supplied with direct-current power at frequent
vals throughout its length. Three-phase alternati
rent is purchased and distributed to trackside s
tions which convert the alternating current to
current.

TRAIN CONTROL AND FARE COLLECTION

It is fundamental that this rapid transit system i
a fully integrated automatic control system, as
the highest degree of safe and reliable servic
achieve the specified high-speed, short-headway
tion of trains over extended periods of time, n
train operation must be completely automatic.
design of all control functions, the "fail-safe" pri
of operation is observed to insure complete safet
failure of any control element causes a train to
in a safe manner, including stopping the train.

supported on steel wheels running on continuous steel rails and operated by automatic train control.

The adoption of this transportation method as a basis for the estimates in this report does not foreclose continuing analysis and possibly ultimate selection of any different or untraditional method. In considering the potential advantages and disadvantages of other methods of rapid transit, comparison can be made with this modern proven system. Any other transit method to be adopted should serve as well or better, and should be of equal or less cost.

The prototype car is 67 feet, 3 inches long; 10 feet, 5 inches wide; and seats 76 passengers. The unloaded weight of the car is under 800 pounds per seat. To achieve the required rates of acceleration each car is self-propelled. Power is supplied by third rail to electric motors driving each of the four axles. Doors are of the sliding type, and the windows are permanently sealed. The interior as well as exterior appearance of the rapid transit car is attractive. Suitable ventilation and cooling and heating, freedom from fumes, and a low noise level are necessary for passenger comfort and satisfaction. Smooth riding qualities are essential.

In addition the vehicle is safe to passengers and employees, and requires the minimum outlay for capital costs of way and equipment and for costs of operating and maintaining the system.

POWER AND PROPULSION

Numerous methods of propulsion and power supply have been studied and evaluated in correlation with the studies of various transit methods. Power supply for a rapid transit system is usually direct-current electrical energy purchased as alternating current and then rectified to direct current. Operation of trains in subways and long tunnels precludes the use of gasoline or diesel powered equipment producing noxious fumes. While some potential does exist for new energy sources in the long-range future, the use of bulk-generated electric energy is still the most practical, efficient, and economical method for today's application.

Three main types of electric motors have characteristics more or less suited to traction applications. The polyphase induction motor is an extremely rugged, low-maintenance, and low-cost motor with the significant advantage that three-phase alternating current could be utilized directly without the necessity of providing rectifying equipment to convert the energy to direct current. This motor, however, is essentially a constant-speed machine, requiring additional transmission devices which introduce complications that offset the advantages of the motor. Also, the problem of transferring polyphase energy from the trackside to the moving car has not yet been solved satisfactorily.

The single-phase series motor has been used in locomotives but it is being replaced by lighter, more efficient propulsion equipment. It does not offer any advantage for the proposed system.

The direct-current series motor is the most widely used for transit purposes. Its design has been developed to a high degree of refinement and today this motor is comparatively light, rugged, compact, and efficient, requiring a minimum of maintenance. Alternative propulsion methods proposed so far have such limitations in performance, current collection, or size and weight that the direct-current series motor is the logical choice now as a basis for estimating costs. This does not preclude ultimate adoption of a superior alternative should one become available prior to the time when final selection must be made.

Direct-current equipment normally is available in three voltage ranges — 750 volts, 1500 volts, and 3000 volts. However, the design of equipment for use on system voltages up to 750 volts is the most highly developed. Such equipment is light and compact, and the required control equipment is reliable and low in cost. Dynamic braking is feasible without complication. Consequently, the lower-voltage equipment has been chosen as the basis of design and estimate.

The proposed method of supplying power to the car from the trackside is a third-rail system. The system is supplied with direct-current power at frequent intervals throughout its length. Three-phase alternating current is purchased and distributed to trackside substations which convert the alternating current to direct current.

TRAIN CONTROL AND FARE COLLECTION

It is fundamental that this rapid transit system include a fully integrated automatic control system, assuring the highest degree of safe and reliable service. To achieve the specified high-speed, short-headway operation of trains over extended periods of time, normal train operation must be completely automatic. In the design of all control functions, the "fail-safe" principle of operation is observed to insure complete safety. The failure of any control element causes a train to react in a safe manner, including stopping the train.

PLATE 2, MISSION LINE, SEE TEXT P. 20

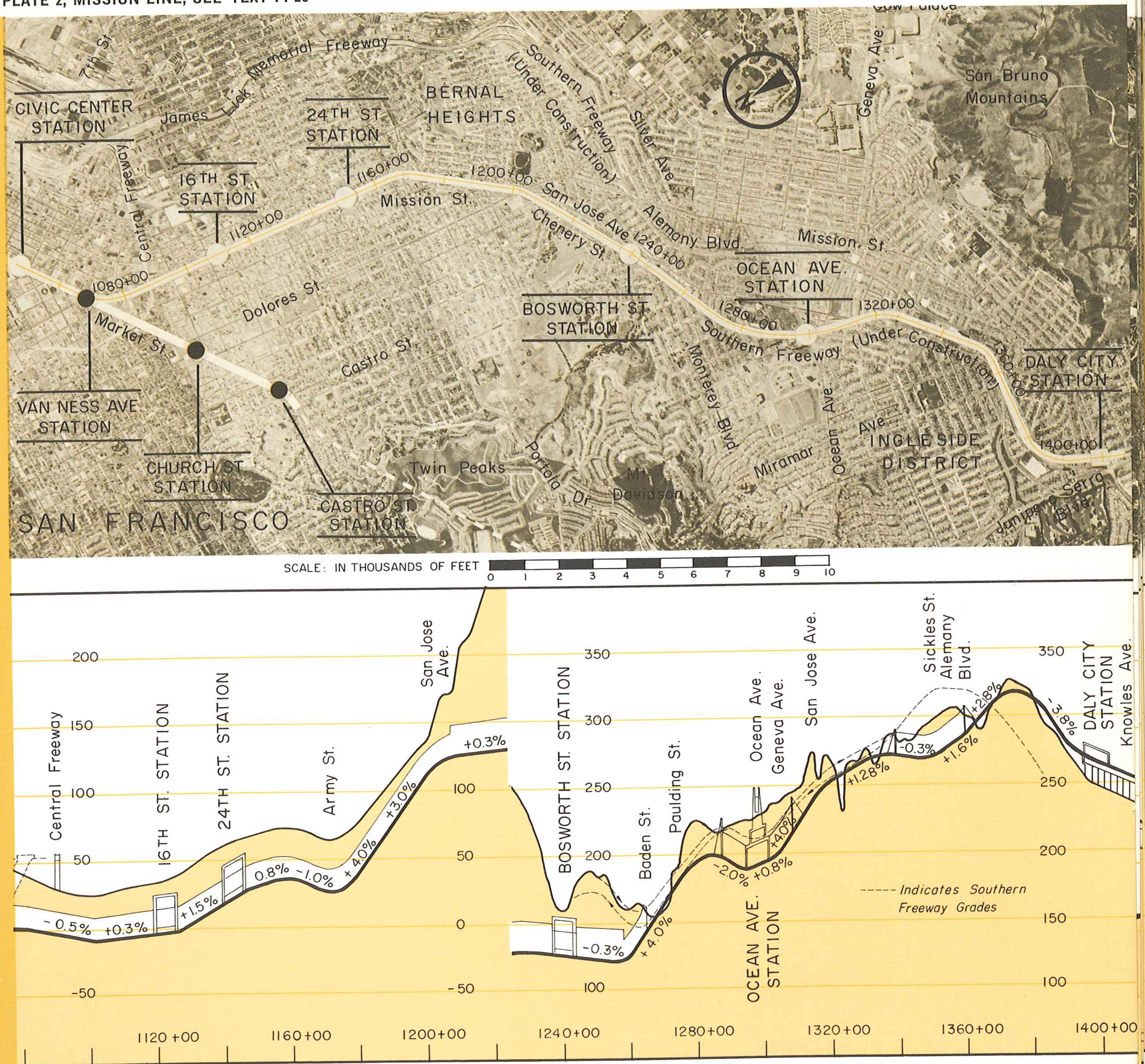
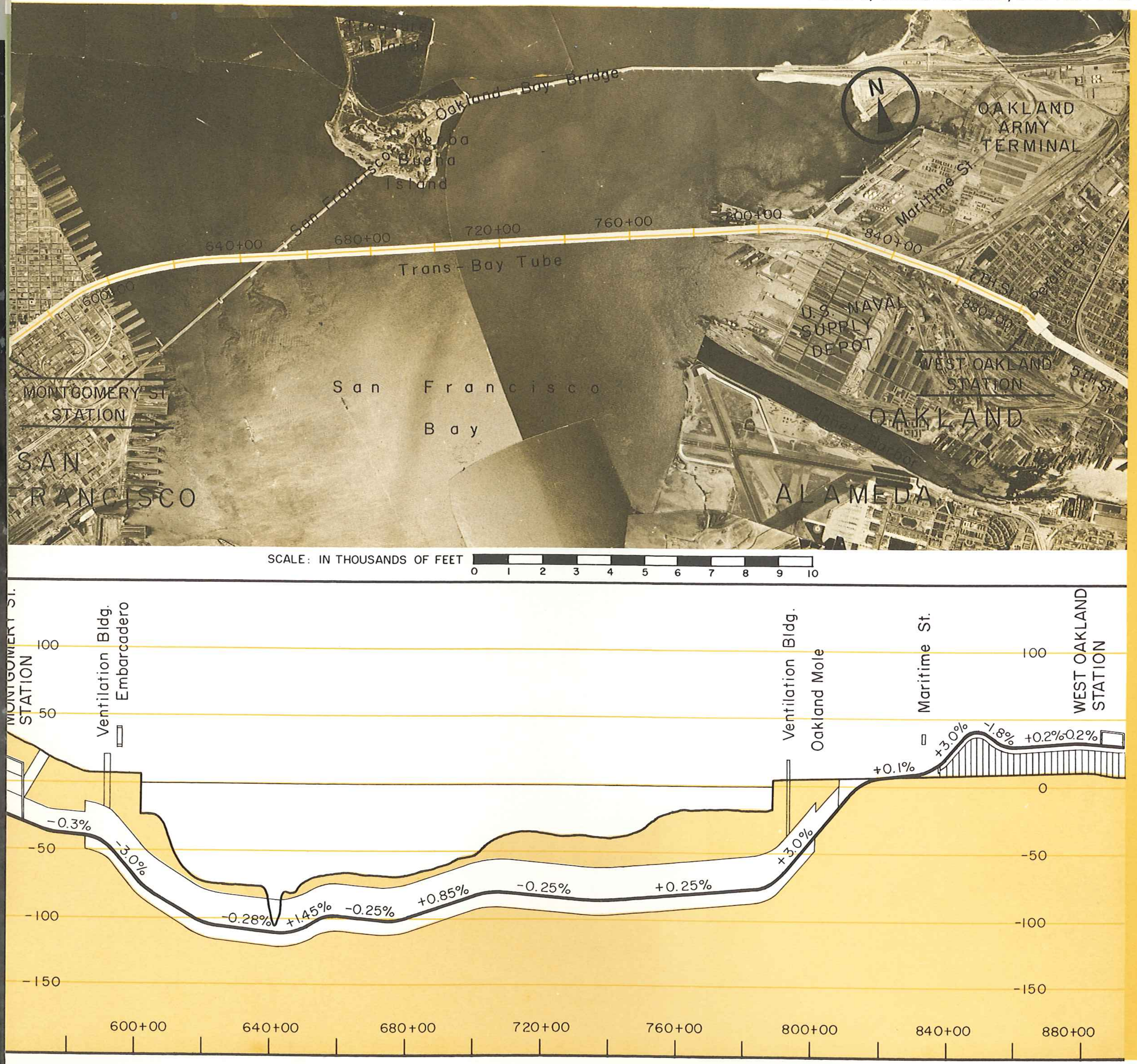


PLATE 3, TRANS-BAY LINE, SEE TEXT P. 20



To achieve complete automatic operation of normal train movement, the control system must be capable of performing a variety of functions through integrated subsystems.

The make-up of each train is determined by traffic and patronage data accumulated in an element of the *central supervisory control system*. Daily conditions affecting the movement of people and traffic are evaluated to determine the frequency and size of trains dispatched. A coded train number in the *train identification system* is available to other control components along the route, which react to set turnouts for proper routing and to determine the proper stopping points at station platforms.

The *route control system* governs movement of trains between stations by controlling the acceleration, running speed, and deceleration to conform to safe, predetermined speed limits applicable to each section of track. A *block control system* performs a similar function and is capable of overriding all other forms of control, either manual or automatic, to cause a train to decrease speed or to stop should it approach too close to another train. Thus, a specific minimum spacing between trains is always maintained, maximum safe speed limits cannot be exceeded, and if a specific command is not received at all times, the train comes to a stop.

The *passenger station control system* assumes control of the train as it approaches a station, and automatically stops the train at a predetermined position. The doors are opened and closed, the train is automatically started, and the control is returned to the route control system.

The *train-borne control system* detects commands or transmits information to trackside or other locations. As a received command is interpreted, the electrical controls of the train are altered as necessary to obey the command.

The heart of the automatic control system is an industrial type control computer. This computer monitors the operation of the entire system by constantly checking the location and movement of all trains, announcing abnormal conditions, adjusting the stopping time at stations to meet local requirements, and performing many other system-wide control functions.

A single attendant aboard each train visually monitors the operation of the train. He normally performs no function except to observe an annunciator or display panel and watch the track for physical obstructions. The only overriding operating functions he can perform are to reduce speed or stop the train.

The flexibility of control and communications afforded by the automatic control system concept leads directly to the incorporation of an automatic charge-account *fare collection system* designed particularly for the convenience of the regular commuter. The standards of operation of the fare collection system are correlated with the standards established for the entire transit concept. Large numbers of passengers must be accommodated without delays, and the fare collection operation, whether cash or credit, must be simple, convenient and accurate.

The cash-fare passenger purchases a coded card or token for the trip which indicates the boarding point and the fare paid. This permits entry to the system. At his destination, the token is deposited in an exit turnstile which determines whether the correct fare was paid.

The charge-account passenger inserts his identification card in a turnstile, which records his identification and boarding point. A similar operation at the exit turnstile records his destination. This information is sent to the central digital computer, correlated, and the fare added to the rider's charge account. The charge-account system with its automatic recording and billing offers simplicity and convenience for the passenger. This modern method of charging for service is expected to encourage and retain patronage.

TRANSIT STRUCTURES

In developing the routes, three basic types of construction are utilized — surface or on-grade construction, elevated or aerial construction, and underground construction. All three — together with any modification — must provide a fully grade-separated right of way.

The rapid transit facility can be constructed on grade close to the ground surface where appropriate rights of way are available or are attainable reasonably. This type of construction is often least expensive, the stations are most readily accessible, and it blends with the surroundings. Surface construction is proposed alongside existing railroads, on median areas of freeways, and on rural private rights of way.

Depressed or open-cut construction is a modification of on-grade construction. The transit facility is placed in an open excavation, of sufficient depth to permit ground-level overpasses to serve cross traffic. Another variation is the placing of the facility on fill or embankment above the level of the existing ground. Cross traffic is then carried through underpasses beneath the transit line.

To achieve complete automatic operation of normal train movement, the control system must be capable of performing a variety of functions through integrated subsystems.

The make-up of each train is determined by traffic and patronage data accumulated in an element of the *central supervisory control system.* Daily conditions affecting the movement of people and traffic are evaluated to determine the frequency and size of trains dispatched. A coded train number in the *train identification system* is available to other control components along the route, which react to set turnouts for proper routing and to determine the proper stopping points at station platforms.

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TRANSIT STRUCTURES

In developing the routes, three basic types of construction are utilized – surface or on-grade construction, elevated or aerial construction, and underground construction. All three – together with any modification – must provide a fully grade-separated right of way.

The rapid transit facility can be constructed on grade close to the ground surface where appropriate rights of way are available or are attainable reasonably. This type of construction is often least expensive, the stations are most readily accessible, and it blends with the surroundings. Surface construction is proposed alongside existing railroads, on median areas of freeways, and on rural private rights of way.

Depressed or open-cut construction is a modification of on-grade construction. The transit facility is placed in an open excavation, of sufficient depth to permit ground-level overpasses to serve cross traffic. Another variation is the placing of the facility on fill or embankment above the level of the existing ground. Cross traffic is then carried through underpasses beneath the transit line.

PLATE 4, OAKLAND DOWNTOWN, SEE TEXT P. 21

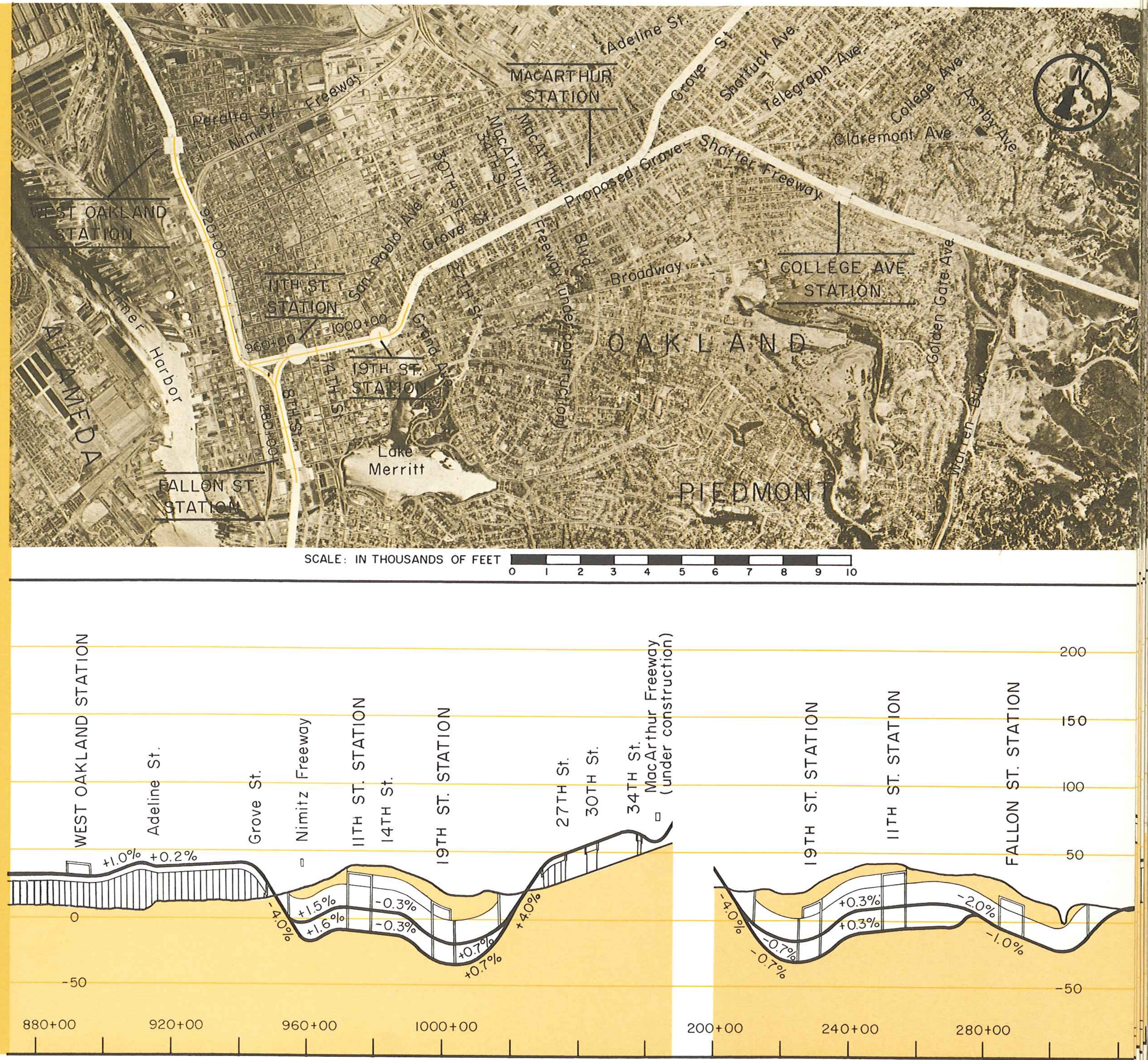
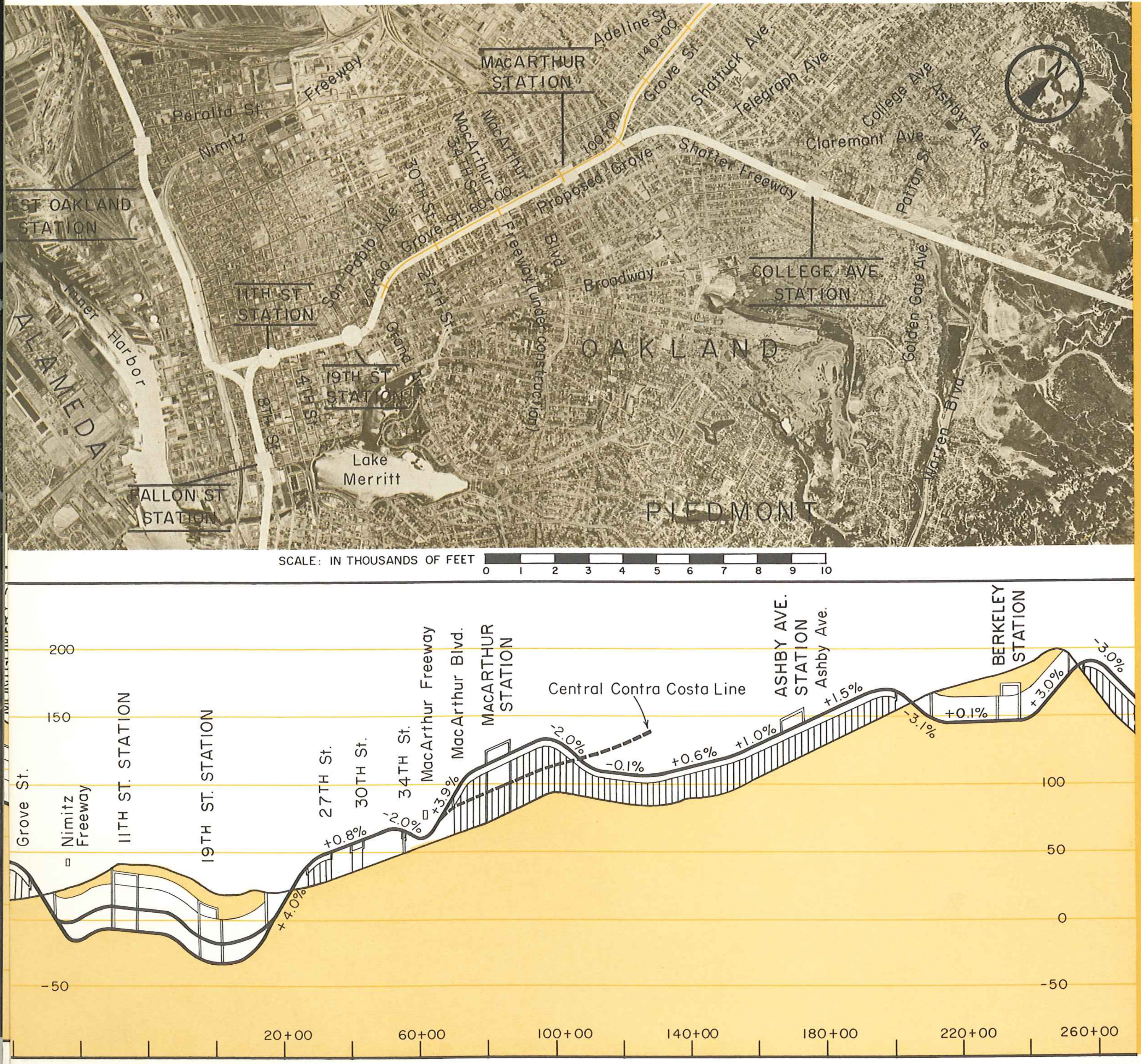


PLATE 5, BERKELEY-RICHMOND LINE (OAKLAND), SEE TEXT P. 22



PARSONS BRINCKERHOFF-TUDOR-BECHTEL, ENGINEERS

In aerial construction the transit facility is placed on narrow elevated structures, making virtually unlimited circulation available for cross traffic. Aerial construction is considered acceptable in streets having a minimum width between building lines of 100 feet. This provides separation of the transit structure from adjacent buildings and results in a light, shadow-free thoroughfare for the pedestrian and the property owner. Aerial structures are located in the center of wide streets, on boulevard median strips, alongside railroads and freeways, and on private rights of way.

Underground construction is the most expensive. It is utilized only where physical barriers necessitate it, or where above-surface space is not available for transit or is prohibitively expensive. In underground construction a distinction must be made between subways and tunnels. As applied to the transit system a subway is an underground railway involving stations accessible from the surface, and it is most usually under an urban street. A subway makes possible the direct delivery of passengers to densely built-up and congested downtown centers. A tunnel, on the other hand, is a continuous underground passage through or under a physical barrier. Examples are the tunnel through the Berkeley Hills and the underwater crossing of San Francisco Bay.

A prior report concerning the Trans-Bay Tube was submitted by Parsons Brinckerhoff-Tudor-Bechtel to the District in July 1960. The "Trans-Bay Tube Engineering Report" contains a detailed discussion of the design, construction and alignment of the tube. Our principal observations and findings are:

- Construction of the Trans-Bay Tube is entirely feasible from the engineering standpoint.
- Stresses induced in the tube by earthquakes are not of sufficient magnitude to exert a controlling influence on the design of the structure.
- Use of a precast concrete tube with metal shell for the underwater crossing between shore points is recommended.
- Use of twin shield-driven tubes for the San Francisco approach into Market Street will reduce street interference and disturbance to the Ferry Building.
- Cut-and-cover construction in a braced trench should be used for the Oakland approach into the Oakland Mole.

STATIONS

The regional rapid transit system transports people between outlying suburban areas and the central core areas, and the transit stations are the points where
passengers gain access to the system. Those station
the suburban centers usually collect passengers f
large residential areas, and it is necessary that loa
and parking provisions be made to handle local fe
facilities such as buses and private automobiles.
tions in downtown districts deliver passengers gene
ly within walking distance of most business cent
which are the destinations of the majority of the
sengers. At these stations, parking facilities are
required.

At the time of final design each station must be
tailed to fit its specific site, purpose, and flow of
trons. At this present stage of the studies, typical
tion designs are considered adequate. Typical des
include on-grade, aerial, and subway stations for
the various combinations of number of tracks, p
form types, mezzanine arrangements, and single
multi-level stations.

Adequately-wide platforms are provided at all
tions; and for safety and convenience, large cl
ances are maintained between the platform edges
the columns, stairwells, and walls. Aerial stations h
stairways and reversible escalators between the gro
floor and platform levels, and subway stations h
stairways and reversible escalators between the me
nine and platform levels. Full-length mezzanines
provided in and between all downtown subway stati
to reduce sidewalk congestion and facilitate di
access to adjacent buildings.

YARDS AND SHOPS

There are three strategically located line yards and
central main yard. Each line yard contains tracks
storage of cars, facilities for making up trains,
provisions for cleaning, inspection, and routine m
tenance of the equipment. The main yard provides
these functions and in addition has facilities for m
repairs and heavy maintenance.

THE ROUTES

The pattern of development in the San Francisco
Area is influenced largely by topography. The pri
pal centers are well established, and the main tr
corridors are well defined. The proposed system
rapid transit is oriented to serve these centers of
velopment and to follow these established travel co
dors. Future extensions and possible expansion of
system have also been anticipated in the developm

In aerial construction the transit facility is placed on narrow elevated structures, making virtually unlimited circulation available for cross traffic. Aerial construction is considered acceptable in streets having a minimum width between building lines of 100 feet. This provides separation of the transit structure from adjacent buildings and results in a light, shadow-free thoroughfare for the pedestrian and the property owner. Aerial structures are located in the center of wide streets, on boulevard median strips, alongside railroads and freeways, and on private rights of way.

Underground construction is the most expensive. It is utilized only where physical barriers necessitate it, or where above-surface space is not available for transit or is prohibitively expensive. In underground construction a distinction must be made between subways and tunnels. As applied to the transit system a subway is an underground railway involving stations accessible from the surface, and it is most usually under an urban street. A subway makes possible the direct delivery of passengers to densely built-up and congested downtown centers. A tunnel, on the other hand, is a continuous underground passage through or under a physical barrier. Examples are the tunnel through the Berkeley Hills and the underwater crossing of San Francisco Bay.

A prior report concerning the Trans-Bay Tube was submitted by Parsons Brinckerhoff-Tudor-Bechtel to the District in July 1960. The "Trans-Bay Tube Engineering Report" contains a detailed discussion of the design, construction and alignment of the tube. Our principal observations and findings are:

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- Use of twin shield-driven tubes for the San Francisco approach into Market Street will reduce street interference and disturbance to the Ferry Building.
- Cut-and-cover construction in a braced trench should be used for the Oakland approach into the Oakland Mole.

STATIONS

The regional rapid transit system transports people between outlying suburban areas and the central core areas, and the transit stations are the points where the passengers gain access to the system. Those stations in the suburban centers usually collect passengers from large residential areas, and it is necessary that loading and parking provisions be made to handle local feeder facilities such as buses and private automobiles. Stations in downtown districts deliver passengers generally within walking distance of most business centers, which are the destinations of the majority of the passengers. At these stations, parking facilities are not required.

At the time of final design each station must be detailed to fit its specific site, purpose, and flow of patrons. At this present stage of the studies, typical station designs are considered adequate. Typical designs include on-grade, aerial, and subway stations for all the various combinations of number of tracks, platform types, mezzanine arrangements, and single and multi-level stations.

Adequately-wide platforms are provided at all stations; and for safety and convenience, large clearances are maintained between the platform edges and the columns, stairwells, and walls. Aerial stations have stairways and reversible escalators between the ground floor and platform levels, and subway stations have stairways and reversible escalators between the mezzanine and platform levels. Full-length mezzanines are provided in and between all downtown subway stations to reduce sidewalk congestion and facilitate direct access to adjacent buildings.

YARDS AND SHOPS

There are three strategically located line yards and one central main yard. Each line yard contains tracks for storage of cars, facilities for making up trains, and provisions for cleaning, inspection, and routine maintenance of the equipment. The main yard provides for these functions and in addition has facilities for major repairs and heavy maintenance.

THE ROUTES

The pattern of development in the San Francisco Bay Area is influenced largely by topography. The principal centers are well established, and the main travel corridors are well defined. The proposed system of rapid transit is oriented to serve these centers of development and to follow these established travel corridors. Future extensions and possible expansion of the system have also been anticipated in the development

PLATE 6, BERKELEY-RICHMOND LINE (BERKELEY, ALBANY), SEE TEXT P. 22

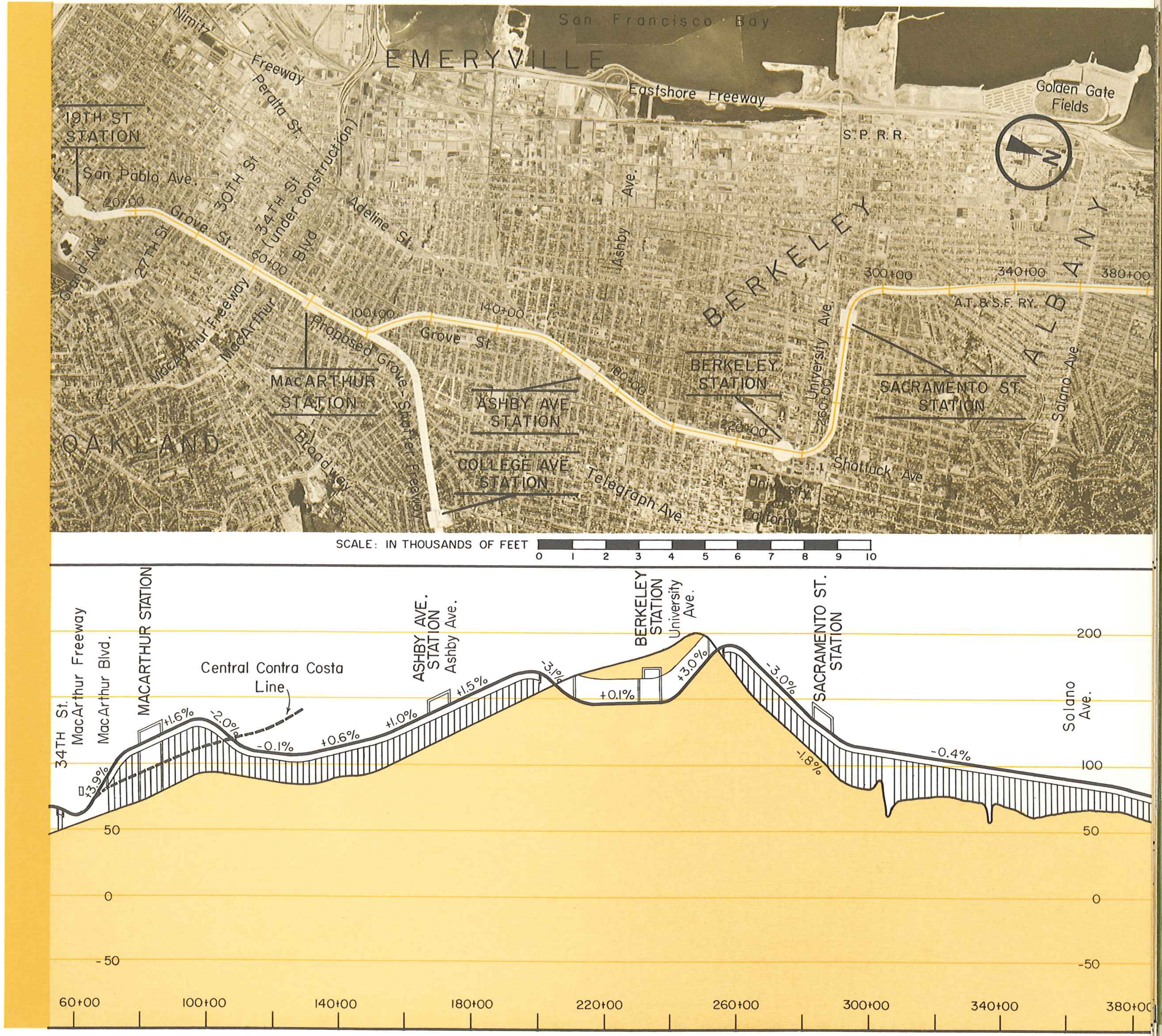
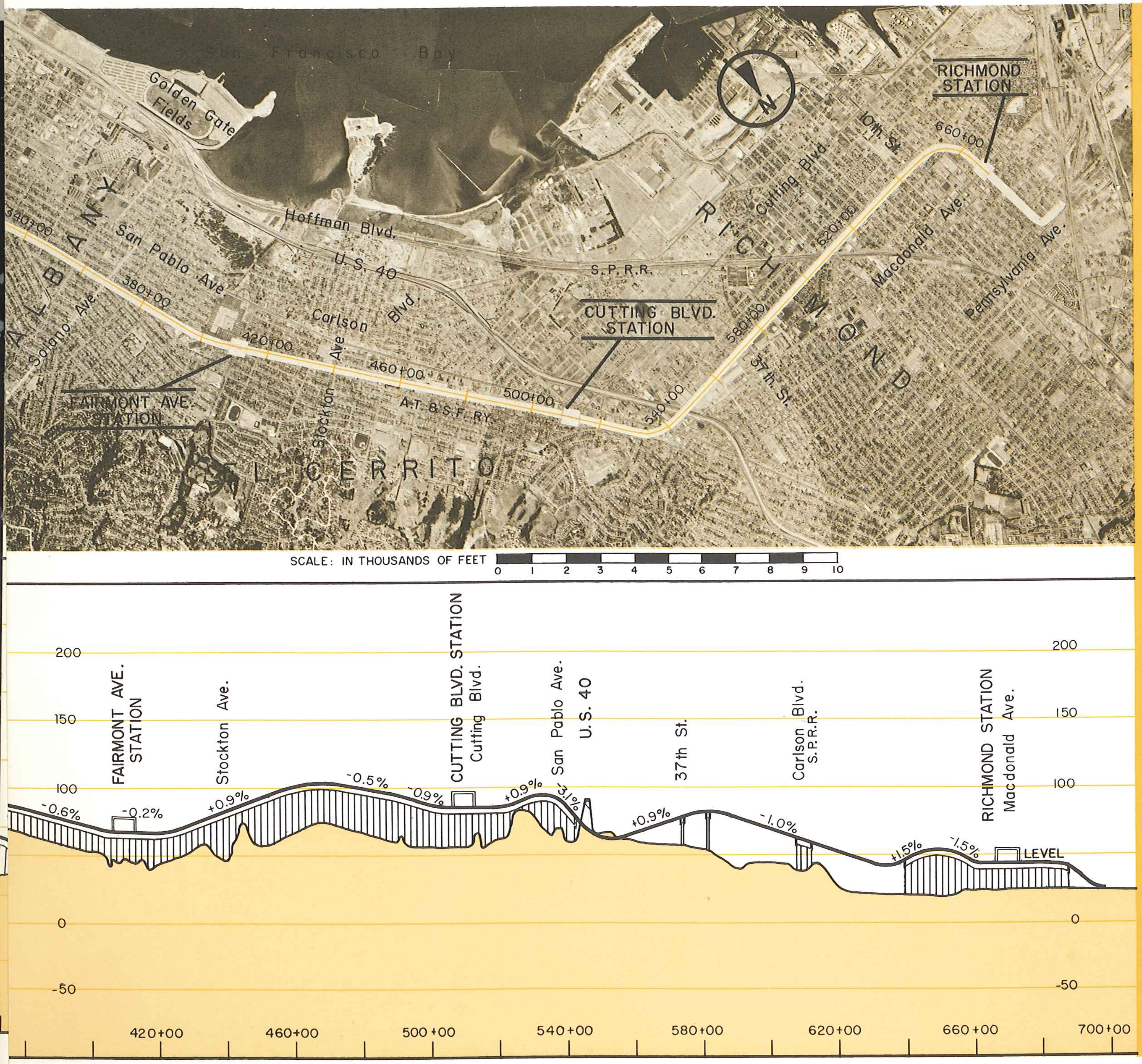


PLATE 7, BERKELEY-RICHMOND LINE (EL CERRITO, RICHMOND), SEE TEXT P. 22



PARSONS BRINCKERHOFF-TUDOR-BECHTEL, ENGINEERS

of routes.

In selecting routes and types of construction, alternatives and evaluations were presented to the San Francisco Bay Area Rapid Transit District in a series of engineering reports. Upon due consideration and consultation with all concerned, the plan which is generally described herein was devised and used as a basis for this report.

The system includes stations serving the downtown areas of San Francisco and Oakland, which have dense business populations. Connecting lines and stations serve the interrelated communities of the Bay Area. West Bay and East Bay are connected by the Trans-Bay line with several rapid transit lines radiating from this central-core area.

From downtown Oakland, the Berkeley-Richmond Line proceeds through Berkeley and into Contra Costa County. The Central Contra Costa Line pierces the Berkeley Hills to the east and serves central Contra Costa County. The Southern Alameda County Line serves the south East Bay. From downtown San Francisco, the Mission Line crosses San Francisco to the south and proceeds to Daly City. The Twin Peaks Line serves the western part of San Francisco County initially through the use of streetcar operations.

For estimating purposes the system is divided into eight major segments: San Francisco Downtown, Mission Line, Twin Peaks Line, Trans-Bay Line, Oakland Downtown, Berkeley-Richmond Line, Central Contra Costa Line, and Southern Alameda County Line. The descriptions on these pages specify the segment boundaries. In the section on estimates, construction costs are listed for each segment.

In all, there are about 75 miles of two-track rapid transit line and 37 stations. Underground construction is proposed for 20 miles, aerial construction for 31 miles, and on-grade construction for 24 miles. The underground portion includes about 11 miles of subway, 5 miles of tunnels, and 4 miles of subaqueous tube.

SAN FRANCISCO DOWNTOWN AND TWIN PEAKS LINE

(Plate 1, p. 12)

The San Francisco Downtown element of the Bay Area regional rapid transit system consists of a four-track, two-level subway beneath Market Street from the Trans-Bay Tube to Van Ness Avenue and a two-track, single-level subway from Van Ness Avenue to the existing Twin Peaks Tunnel.

At Montgomery Street, the lower level of the Market Street subway joins the San Francisco approach to the Trans-Bay Tube. This level extends to about Van Ness Avenue, where it leaves Market Street to connect with the subway in Mission Street. The two-track subway proceeds along Mission Street and at 14th Street becomes the Mission Line.

The upper level and the subway to Twin Peaks are built to accommodate rapid transit trains at a future time and will be utilized initially by streetcars of the San Francisco Municipal Railway.

Both levels of the Market Street subway are served by three stations in Market Street. The Montgomery Street Station serves the financial district; the Powell Street Station serves the commercial and shopping area; and the Civic Center Station serves the Civic Center and vicinity. These stations have full mezzanines and are connected by a continuous mezzanine providing effective distribution of patrons.

In Market Street west of Civic Center, stations are provided at Van Ness Avenue, Church Street, and Castro Street. Ramp connections are provided just off Market Street to surface streetcar operations in Duboce Avenue and Church Street.

West of Twin Peaks a rapid transit subway for initial use by streetcars is planned extending from the existing Twin Peaks Tunnel to a point just west of St. Francis Circle where surface operations resume. The West Portal Station is in subway in West Portal Avenue at Vicente Street. Ramp connections to surface streetcar operations are included in Ulloa Street and Junipero Serra Boulevard. This section west of Twin Peaks is identified as the Twin Peaks Line.

All five streetcar lines operate beneath Market Street in the downtown area to the general vicinity of Beale Street. One-way ramp connections are provided in both Front and Davis Streets between California Street and Market Street to permit the return to surface operations.

The Market Street subway and the connection to the Mission Line are 1.9 miles long and include three stations. The Market Street connection to the existing Twin Peaks Tunnel is 1.4 miles long and includes three stations. The Twin Peaks Line is 0.8 miles long and includes one station.

of routes.

In selecting routes and types of construction, alternatives and evaluations were presented to the San Francisco Bay Area Rapid Transit District in a series of engineering reports. Upon due consideration and consultation with all concerned, the plan which is generally described herein was devised and used as a basis for this report.

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In all, there are about 75 miles of two-track rapid transit line and 37 stations. Underground construction is proposed for 20 miles, aerial construction for 31 miles, and on-grade construction for 24 miles. The underground portion includes about 11 miles of subway, 5 miles of tunnels, and 4 miles of subaqueous tube.

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All five streetcar lines operate beneath Market Street in the downtown area to the general vicinity of Beale Street. One-way ramp connections are provided in both Front and Davis Streets between California Street and Market Street to permit the return to surface operations.

The Market Street subway and the connection to the Mission Line are 1.9 miles long and include three stations. The Market Street connection to the existing Twin Peaks Tunnel is 1.4 miles long and includes three stations. The Twin Peaks Line is 0.8 miles long and includes one station.

PLATE 8, CENTRAL CONTRA COSTA LINE (OAKLAND), SEE TEXT P. 23

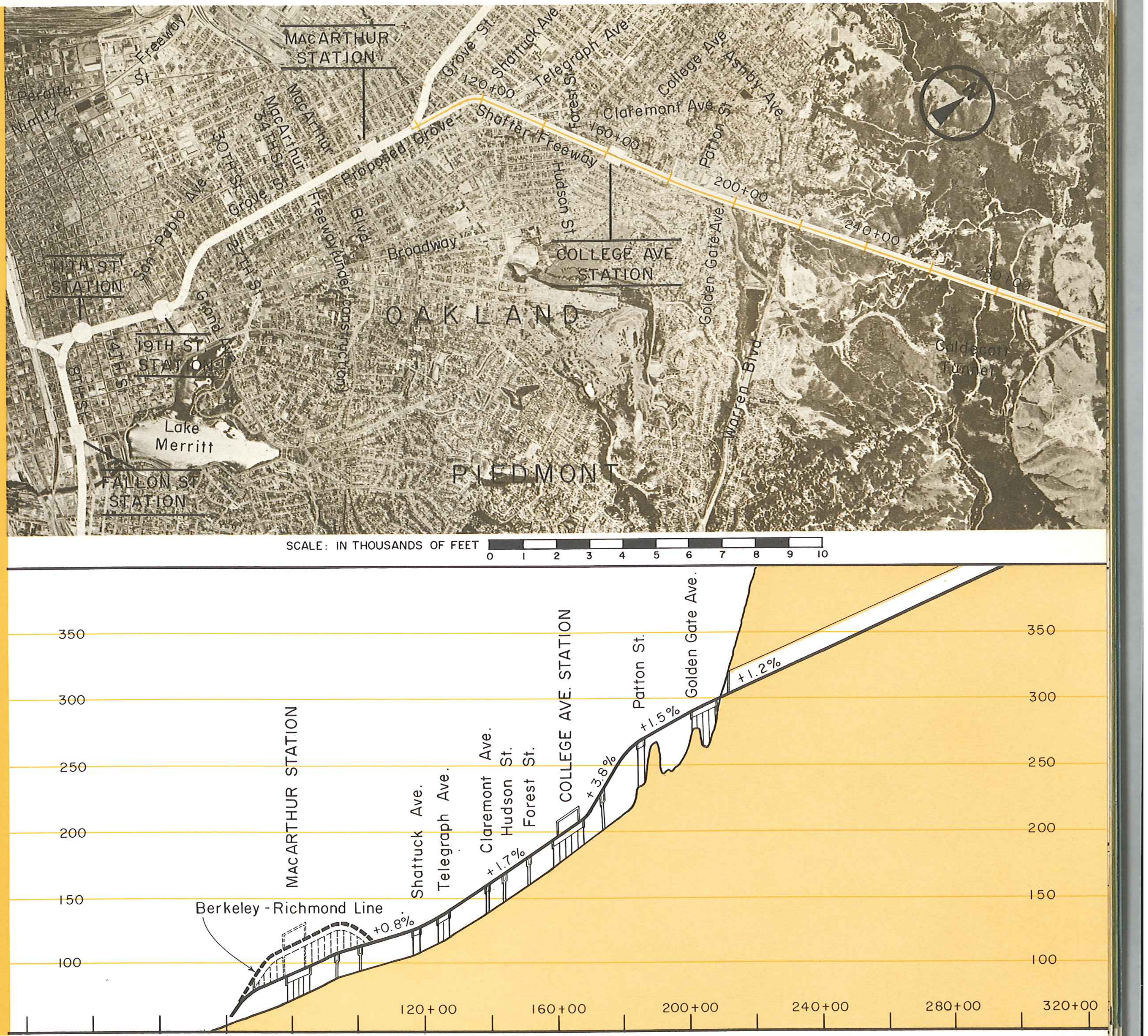
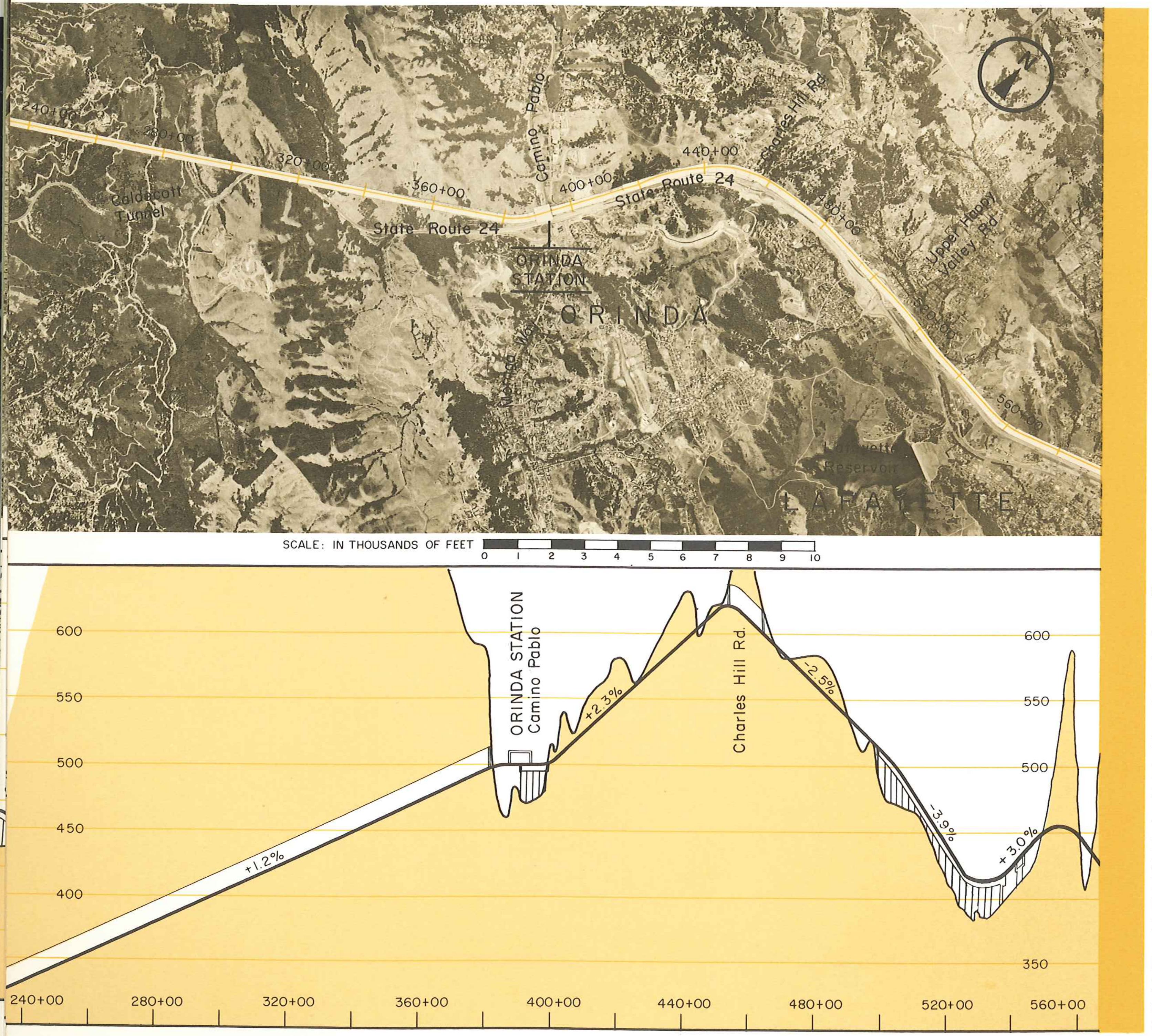


PLATE 9, CENTRAL CONTRA COSTA LINE (ORINDA), SEE TEXT P. 23



PARSONS BRINCKERHOFF-TUDOR-BECHTEL, ENGINEERS

MISSION LINE

(Plate 2, p. 13)

The Mission Line leaves San Francisco Downtown via Mission Street, beginning at 14th Street. The two-track, single-level subway beneath Mission Street includes stations at 16th and 24th Streets in the Mission District.

Near 30th Street the subway leaves Mission Street and swings westward through a tunnel under Bernal Heights to a subway station beneath Diamond Street at Bosworth Street. Continuing underground the line crosses under Monterey Boulevard and enters the alignment of the Southern Freeway.

At the Baden Street overcrossing the tracks come to the surface in the median of the freeway, and at Ocean Avenue a center-platform station is planned. At Sickles Street the tracks leave the freeway median in tunnel beneath the eastbound Southern Freeway lanes, Alemany Boulevard, and San Jose Avenue. An on-grade section between the freeway and DeLong Street carries the line into Daly City.

Entering Daly City the line rises on aerial structure along the east side of the proposed Junipero Serra-Southern Freeway interchange to a terminal station just north of Knowles Avenue.

The Mission Line is 6.0 miles long and includes five stations.

THE TRANS-BAY LINE

(Plate 3, p. 14)

The Trans-Bay Line consists of the Trans-Bay Tube and its approaches, connecting San Francisco and Oakland.

The San Francisco approach joins San Francisco Downtown at the east end of the Montgomery Street Station in Market Street and extends to the west ventilation building located at the south corner of The Embarcadero and Market Street. The Market Street subway is extended by cut-and-cover construction to Beale Street, where the upper level turns into Davis Street. There a transition section from the lower level leads to twin shield-driven tubes which carry the tracks beneath The Embarcadero and the south wing of the Ferry Building.

The Trans-Bay Tube begins at the west ventilation building and extends across the Bay to the east ventilation building. The subaqueous tube follows an alignment between Piers W4 and W5 of the San Francisco-Oakland Bay Bridge and to the opposite shore. At the Oakland Mole the tracks come to surface after passin through a subway section.

The Oakland approach to the tube extends fro the east ventilation building to the West Oakland Station. The tracks are on grade leaving the Oaklan Mole, passing beneath the Maritime Street overpass The line rises on aerial structure to cross over track of the Southern Pacific Railroad and to occupy th median of a widened 7th Street. Proceeding east o 7th Street to Peralta Street, the Trans-Bay Line reaches the West Oakland Station, which is the beginning o the Oakland Downtown segment.

The Trans-Bay Line including the tube and its approaches is 6.0 miles long.

OAKLAND DOWNTOWN

(Plate 4, p. 15)

The Oakland Downtown segment is the junction o the three radial East Bay lines and the Trans-Bay Line The route into downtown Oakland from the Trans-Bay Line begins at the West Oakland Station near Peralta Street. The line is on aerial structure in privat right of way, paralleling 5th Street. At Grove Stree the line descends to subway, curves northward, an passes beneath Washington and 5th Streets, the elevated Nimitz Freeway structure, and Broadway. Underground track connections permit direct movemen of trains between the Broadway subway, the Souther Alameda County Line and the Trans-Bay Line.

The heart of the Oakland complex is the three-track, two-level subway in Broadway. On the two-trac upper level, northbound trains operate to Richmon or Concord along with express trains to and from Sa Francisco. On the lower level, southbound trains operate to Fremont or San Francisco. This complex includes the 11th Street Station and the 19th Street Station. Both have mezzanines which are connected b an underground mall or walkway, providing distribution of patrons to the street level and to adjacen buildings.

North of the 19th Street Station, the subway curve westward toward the Grove-Shafter Freeway and passes beneath private property, 23rd Street, Telegrap Avenue and West Grand Avenue to a portal markin the division between the Oakland Downtown segmen and the Berkeley-Richmond Line. In this section th two-level subway becomes a three-track, one-leve subway.

Oakland Downtown also includes the subway i 8th Street which joins the Southern Alameda Count

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Near 30th Street the subway leaves Mission Street and swings westward through a tunnel under Bernal Heights to a subway station beneath Diamond Street at Bosworth Street. Continuing underground the line crosses under Monterey Boulevard and enters the alignment of the Southern Freeway.

At the Baden Street overcrossing the tracks come to the surface in the median of the freeway, and at Ocean Avenue a center-platform station is planned. At Sickles Street the tracks leave the freeway median in tunnel beneath the eastbound Southern Freeway lanes, Alemany Boulevard, and San Jose Avenue. An on-grade section between the freeway and DeLong Street carries the line into Daly City.

Entering Daly City the line rises on aerial structure along the east side of the proposed Junipero Serra-Southern Freeway interchange to a terminal station just north of Knowles Avenue.

The Mission Line is 6.0 miles long and includes five stations.

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The Oakland approach to the tube extends from the east ventilation building to the West Oakland Station. The tracks are on grade leaving the Oakland Mole, passing beneath the Maritime Street overpass. The line rises on aerial structure to cross over tracks of the Southern Pacific Railroad and to occupy the median of a widened 7th Street. Proceeding east on 7th Street to Peralta Street, the Trans-Bay Line reaches the West Oakland Station, which is the beginning of the Oakland Downtown segment.

The Trans-Bay Line including the tube and its approaches is 6.0 miles long.

OAKLAND DOWNTOWN

(Plate 4, p. 15)

The Oakland Downtown segment is the junction of the three radial East Bay lines and the Trans-Bay Line. The route into downtown Oakland from the Trans-Bay Line begins at the West Oakland Station near Peralta Street. The line is on aerial structure in private right of way, paralleling 5th Street. At Grove Street the line descends to subway, curves northward, and passes beneath Washington and 5th Streets, the elevated Nimitz Freeway structure, and Broadway. Underground track connections permit direct movement of trains between the Broadway subway, the Southern Alameda County Line and the Trans-Bay Line.

The heart of the Oakland complex is the three-track, two-level subway in Broadway. On the two-track upper level, northbound trains operate to Richmond or Concord along with express trains to and from San Francisco. On the lower level, southbound trains operate to Fremont or San Francisco. This complex includes the 11th Street Station and the 19th Street Station. Both have mezzanines which are connected by an underground mall or walkway, providing distribution of patrons to the street level and to adjacent buildings.

North of the 19th Street Station, the subway curves westward toward the Grove-Shafter Freeway and passes beneath private property, 23rd Street, Telegraph Avenue and West Grand Avenue to a portal marking the division between the Oakland Downtown segment and the Berkeley-Richmond Line. In this section the two-level subway becomes a three-track, one-level subway.

Oakland Downtown also includes the subway in 8th Street which joins the Southern Alameda County

PLATE 10, CENTRAL CONTRA COSTA LINE (LAFAYETTE, WALNUT CREEK), SEE TEXT P. 23

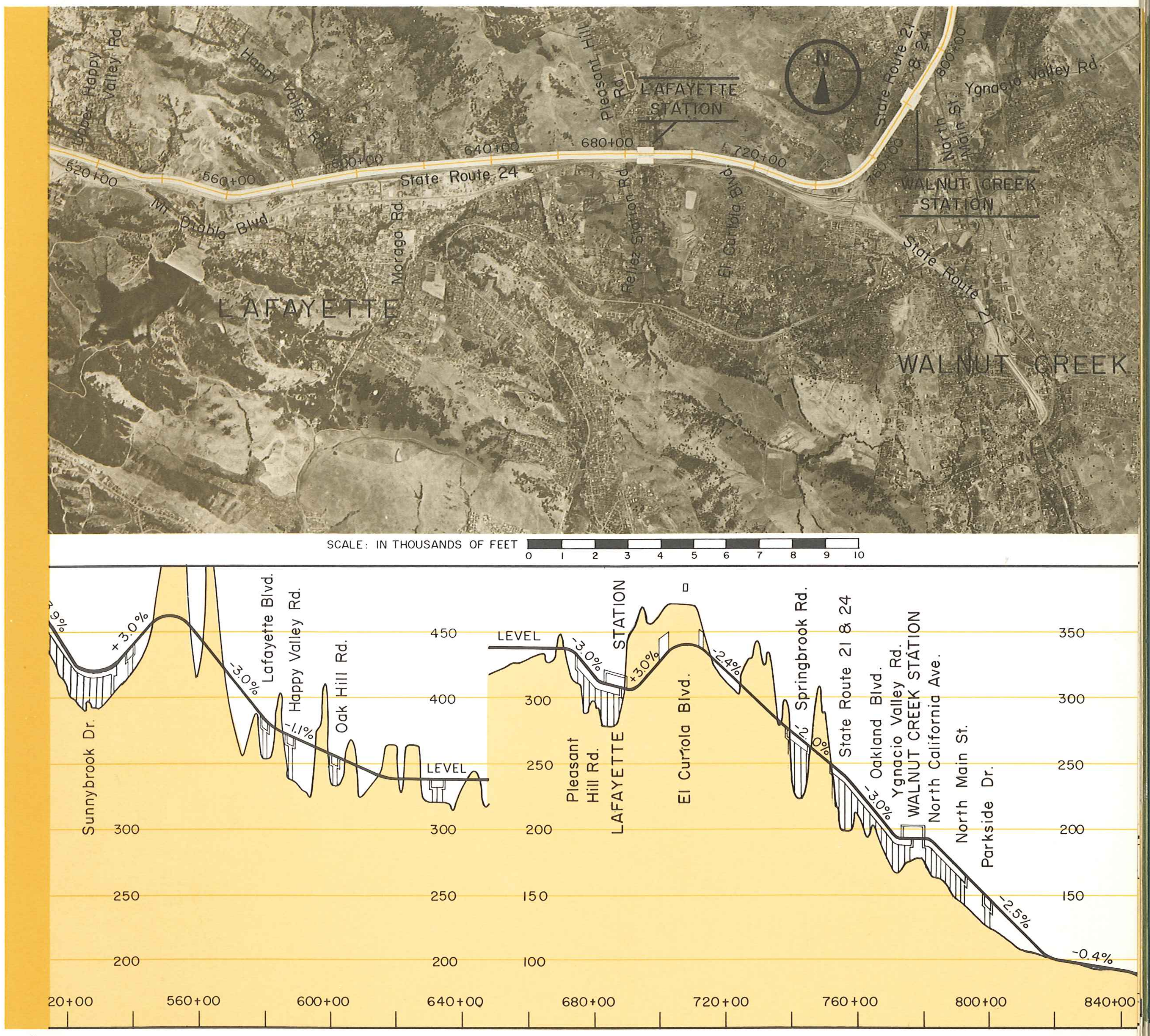
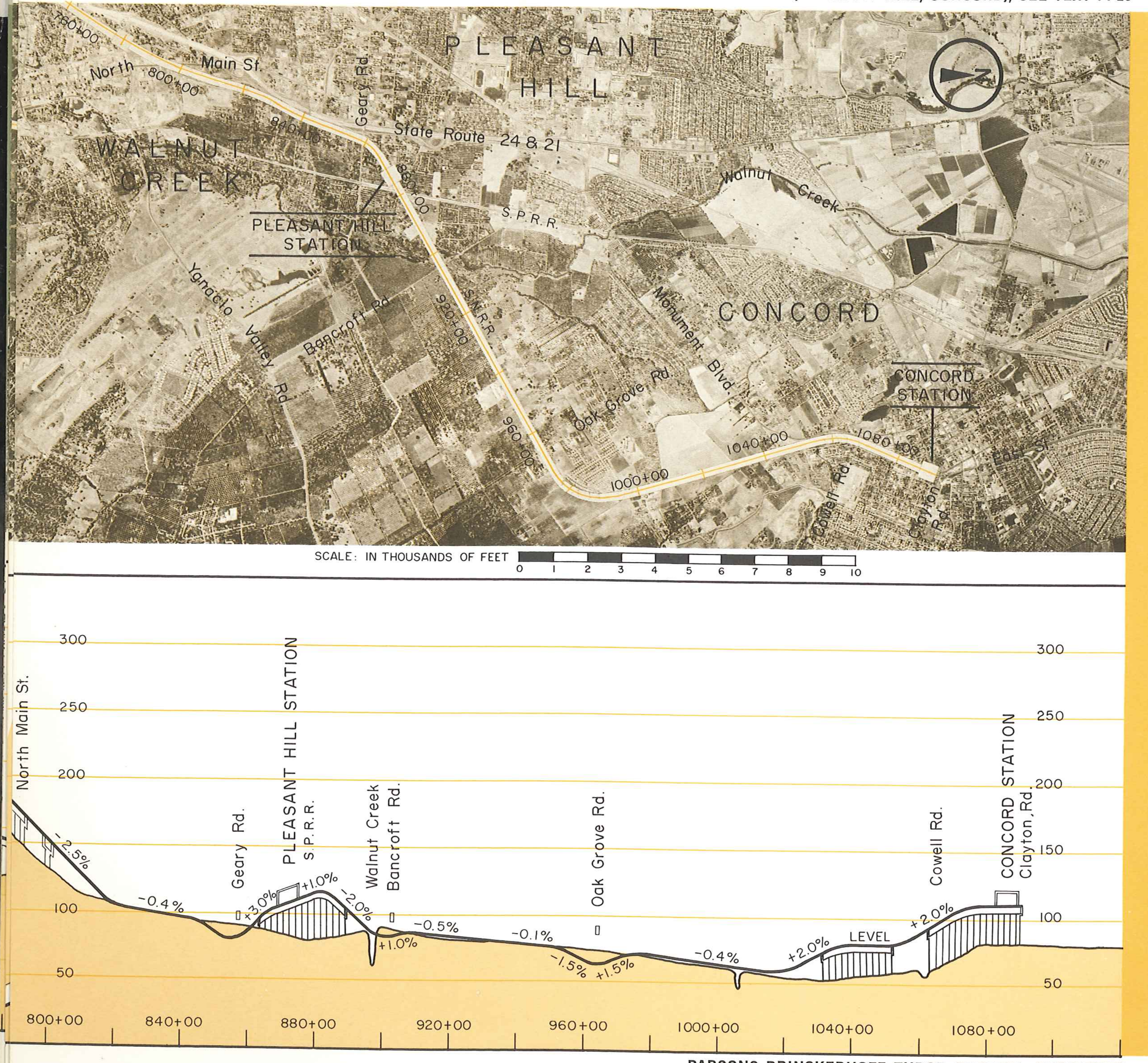


PLATE 11, CENTRAL CONTRA COSTA LINE (PLEASANT HILL, CONCORD), SEE TEXT P. 23



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Line south of the Fallon Street Station.

Oakland Downtown, including the connections to the Trans-Bay Line and to the Southern Alameda County Line, is 3.2 miles long and contains four stations.

THE BERKELEY-RICHMOND LINE

(Plates 5-7, pp. 16-18)

From the northern portal of the Broadway subway, the Berkeley-Richmond Line enters the median of the Grove-Shafter Freeway, passing beneath the northbound freeway lanes. The line, three tracks at this point, continues on embankment or on structure at the same grade as the freeway. At 32nd Street, the rapid transit right of way widens to accommodate a fourth track. All four of these tracks pass beneath the MacArthur Freeway before the center pair of tracks rises on structure to approach the MacArthur Station at 40th Street. This station has two track levels. The lower two tracks continue as the Central Contra Costa Line in the freeway median toward the Berkeley Hills Tunnel. The two tracks to Richmond depart from the upper level of the MacArthur Station and cross over the southbound freeway lanes. Commencing at 45th Street in Oakland, the aerial line proceeds westerly from the freeway to Grove Street.

Along Grove Street, from 45th Street to 63rd Street, the aerial transit line is in the street median. The same mode of construction is continued northward along Adeline Street to the Ashby Avenue Station, which is located in the center of the street, approximately midway between Woolsey Street and Ashby Avenue. From the station the line continues northward along Shattuck Avenue to Derby Street, which marks the beginning of a transition from aerial structure to subway. The subway portal is located at the south side of Dwight Way.

Subway construction is continued through central Berkeley, passing through the Berkeley Station at Center Street and emerging from a portal on the west side of Milvia Street. The Milvia Street portal marks the beginning of a transition back to an aerial structure occupying the median of a widened Hearst Avenue to the Sacramento Street Station. The line curves northward at Francisco Street to join the Atchison, Topeka and Santa Fe Railroad right of way. From this point to Richmond, construction consists of aerial structure along the west side of the railroad. Stations are located at Fairmont Avenue and immediately south of Cutting Boulevard in El Cerrito.

The route enters Richmond parallel to the Santa Fe right of way, passes beneath the Eastshore Freeway and remains to the south of the railroad. Construction alongside the railroad is on embankment. At 10th Street the line crosses over the Santa Fe tracks on aerial structure and turns into the Richmond Station at Macdonald Avenue between 5th and 6th Streets in Richmond. North of the station the line descends to grade to enter the maintenance and storage yard adjacent to Pennsylvania Avenue.

The Berkeley-Richmond Line is 12.8 miles long and has seven stations.

CENTRAL CONTRA COSTA LINE

(Plates 8-11, pp. 19-22)

The Central Contra Costa Line begins north of the MacArthur Station at grade in the median of the elevated Grove-Shafter Freeway. A station is provided at College Avenue. The line continues in the median of the freeway to Patton Street where the rapid transit tracks leave the freeway by crossing in subway under the westbound freeway lanes and enter a 3.3-mile tunnel to the north of, and far below, the existing Caldecott Tunnel. After entering Contra Costa County and emerging from the tunnel at the Orinda Station, the line passes on aerial structure over the ramps of the State Route 24-Camino Pablo interchange.

Proceeding easterly the line remains on the north side and parallel to the freeway all the way to the State Route 21-State Route 24 interchange in Walnut Creek. From Orinda Station to Acalanes Road interchange near Lafayette, construction is on grade except for a tunnel under the crest of the hill at Charles Hill Road. The line bridges over the ramps of the Acalanes Road interchange, Upper Happy Valley Road, and Sunnybrook Drive, then continues eastward on embankment and in cut to the Pleasant Hill Road interchange. Bridge structures are included at Lafayette Boulevard, Happy Valley Road, Oak Hill Road and the aqueducts of the East Bay Municipal Utility District. Aerial structure carries the line over the Pleasant Hill Road interchange to the Lafayette Station.

From the Lafayette Station to the State Route 21-State Route 24 interchange, the line continues on grade, in cut and on embankment except for short underground portions beneath the ramps of El Curtola Boulevard interchange and aerial structure over Hillcrest and Springbrook Roads. The line crosses the freeway on aerial structure at the Oakvale Road overpass in Walnut Creek and continues on structure along and over Oakland Boulevard to the site of the Walnut

Line south of the Fallon Street Station.

Oakland Downtown, including the connections to the Trans-Bay Line and to the Southern Alameda County Line, is 3.2 miles long and contains four stations.

THE BERKELEY-RICHMOND LINE

(Plates 5-7, pp. 16-18)

From the northern portal of the Broadway subway, the Berkeley-Richmond Line enters the median of the Grove-Shafter Freeway, passing beneath the northbound freeway lanes. The line, three tracks at this point, continues on embankment or on structure at the same grade as the freeway. At 32nd Street, the rapid transit right of way widens to accommodate a fourth track. All four of these tracks pass beneath the MacArthur Freeway before the center pair of tracks rises on structure to approach the MacArthur Station at 40th Street. This station has two track levels. The lower two tracks continue as the Central Contra Costa Line in the freeway median toward the Berkeley Hills Tunnel. The two tracks to Richmond depart from the upper level of the MacArthur Station and cross over the southbound freeway lanes. Commencing at 45th Street in Oakland, the aerial line proceeds westerly from the freeway to Grove Street.

Along Grove Street, from 45th Street to 63rd Street, the aerial transit line is in the street median. The same mode of construction is continued northward along Adeline Street to the Ashby Avenue Station, which is located in the center of the street, approximately midway between Woolsey Street and Ashby Avenue. From the station the line continues northward along Shattuck Avenue to Derby Street, which marks the beginning of a transition from aerial structure to subway. The subway portal is located at the south side of Dwight Way.

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The route enters Richmond parallel to the Santa Fe right of way, passes beneath the Eastshore Freeway and remains to the south of the railroad. Construction alongside the railroad is on embankment. At 10th Street the line crosses over the Santa Fe tracks on aerial structure and turns into the Richmond Station at Macdonald Avenue between 5th and 6th Streets in Richmond. North of the station the line descends to grade to enter the maintenance and storage yard adjacent to Pennsylvania Avenue.

The Berkeley-Richmond Line is 12.8 miles long and has seven stations.

CENTRAL CONTRA COSTA LINE

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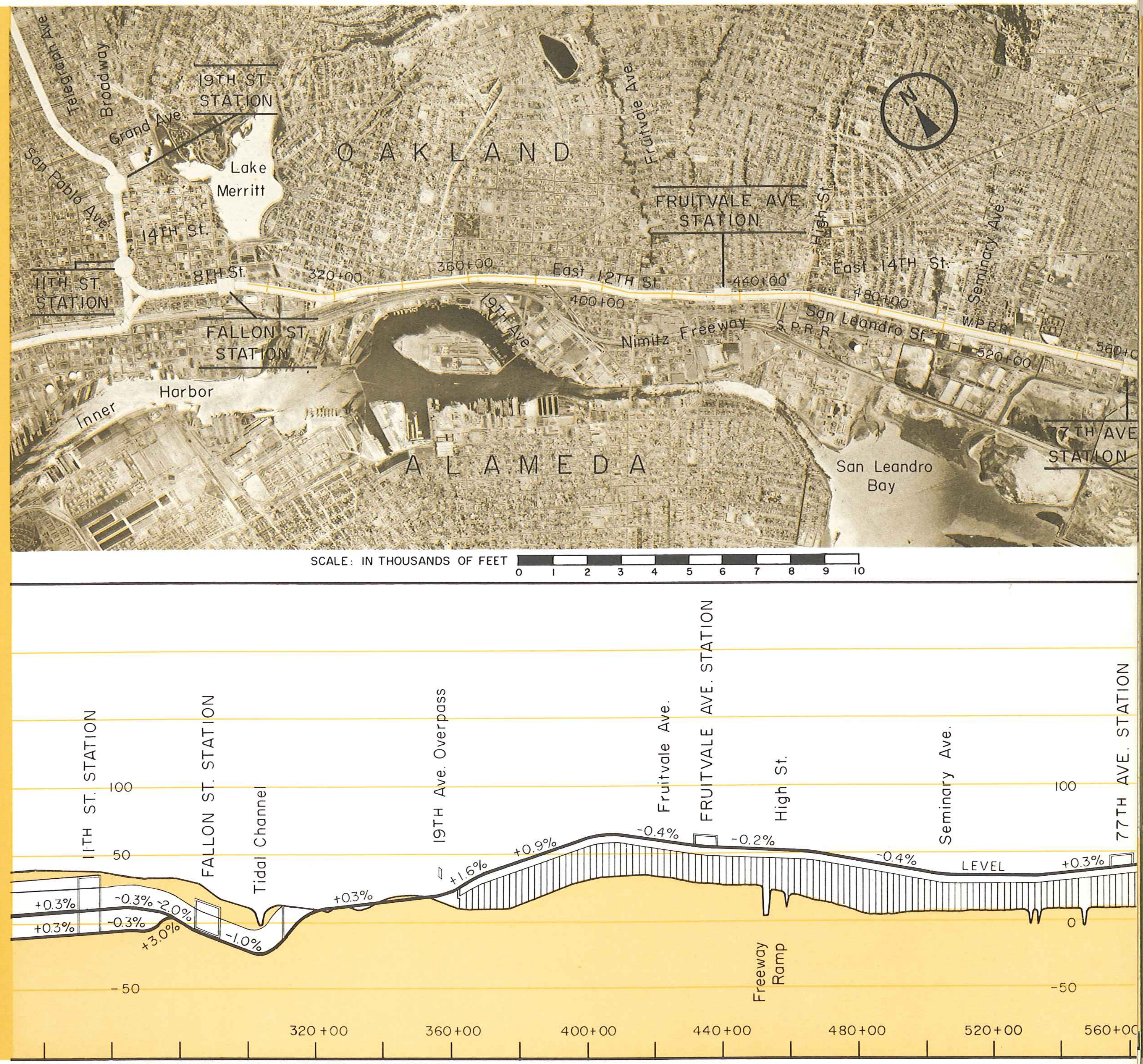
The Central Contra Costa Line begins north of the MacArthur Station at grade in the median of the elevated Grove-Shafter Freeway. A station is provided at College Avenue. The line continues in the median of the freeway to Patton Street where the rapid transit tracks leave the freeway by crossing in subway under the westbound freeway lanes and enter a 3.3-mile tunnel to the north of, and far below, the existing Caldecott Tunnel. After entering Contra Costa County and emerging from the tunnel at the Orinda Station, the line passes on aerial structure over the ramps of the State Route 24-Camino Pablo interchange.

Proceeding easterly the line remains on the north side and parallel to the freeway all the way to the State Route 21-State Route 24 interchange in Walnut Creek. From Orinda Station to Acalanes Road interchange near Lafayette, construction is on grade except for a tunnel under the crest of the hill at Charles Hill Road. The line bridges over the ramps of the Acalanes Road interchange, Upper Happy Valley Road, and Sunnybrook Drive, then continues eastward on embankment and in cut to the Pleasant Hill Road interchange. Bridge structures are included at Lafayette Boulevard, Happy Valley Road, Oak Hill Road and the aqueducts of the East Bay Municipal Utility District. Aerial structure carries the line over the Pleasant Hill Road interchange to the Lafayette Station.

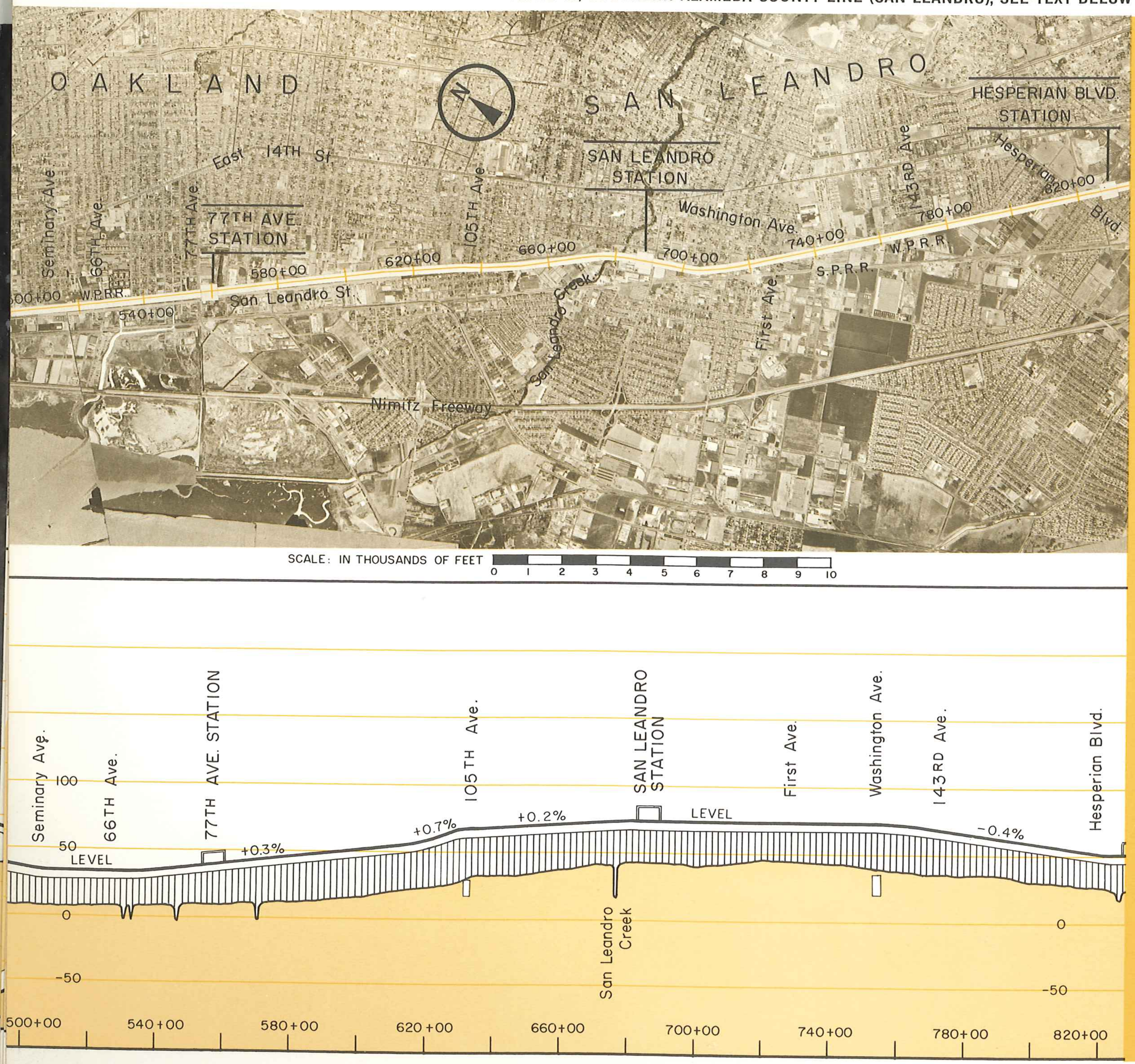
From the Lafayette Station to the State Route 21-State Route 24 interchange, the line continues on grade, in cut and on embankment except for short underground portions beneath the ramps of El Curtola Boulevard interchange and aerial structure over Hillcrest and Springbrook Roads. The line crosses the freeway on aerial structure at the Oakvale Road overpass in Walnut Creek and continues on structure along and over Oakland Boulevard to the site of the Walnut

PLATE 12, SOUTHERN ALAMEDA COUNTY LINE (OAKLAND), SEE TEXT P. 24



PARSONS BRINCKERHOFF-TUDOR-BECHTEL, ENGINEERS

PLATE 13, SOUTHERN ALAMEDA COUNTY LINE (SAN LEANDRO), SEE TEXT BELOW



Creek Station just north of Ygnacio Valley Road. The station is located generally between Riviera and North California Avenues.

North of the Walnut Creek Station the line passes over North California Avenue on aerial structure to an alignment along the Sacramento-Northern Railroad right of way. After crossing North Main Street the line proceeds on embankment and on grade, except for street separation structures at Parkside Drive and Geary Road. After crossing under Geary Road the line rises and utilizes aerial construction to the Pleasant Hill Station in Walden.

Beyond the Pleasant Hill Station the line descends to grade after crossing over the Southern Pacific tracks. Structures provide for Bancroft and Oak Grove Roads to cross over the rapid transit tracks. The rapid transit tracks are on grade east of the Sacramento-Northern Railroad to San Miguel Road and then ascend to aerial structure and proceed into the Concord Station at Clayton Road. A transit vehicle storage yard is located between the Pleasant Hill and Concord Stations.

The Central Contra Costa Line is 18.9 miles long and includes six stations.

SOUTHERN ALAMEDA COUNTY LINE

(Plates 12-16, pp. 23-27)

The Southern Alameda County Line begins near the Exposition Building and beyond the Fallon Street Station in 8th Street in Oakland. Proceeding southward the subway leaves the alignment of 8th Street, passes beneath the channel of Lake Merritt Inlet, and then follows 7th Street. After passing beneath 5th Avenue, the tracks come to the surface along the east side of the Western Pacific Railroad main line tracks. The rapid transit tracks remain on grade along the railroad until they pass beneath the 19th Avenue overcrossing where they rise on aerial structure and enter the median of East 12th Street. The line continues in this median to Fruitvale Avenue. Both the Fruitvale Avenue Station at 36th Avenue and the transit line southward to 47th Avenue are located immediately east of the Western Pacific tracks.

At 47th Avenue the line crosses the Western Pacific tracks to occupy a narrow strip between the railroad and San Leandro Street. The line continues to follow this strip on aerial structure to 105th Avenue, with a station at 77th Avenue. At 105th Avenue, the structure once again crosses to the east side of the Western Pacific tracks, remaining there to Hayward. The aerial San Leandro Station is located at Davis Street. The line continues on structure through San Leandro, and the next station is located at Hesperian Boulevard. The rapid transit tracks descend to grade to pass under the existing U. S. Highway 50 structure. Aerial construction resumes and continues through Hayward. The Hayward Station is located just north of Jackson Street.

The route crosses to the west of the Western Pacific Railroad immediately south of Jackson Street and parallels the railroad. A station is provided at Alquire Road, and the Union City Station is located at Decoto Road. Storage and maintenance facilities are provided at Decoto Road.

At Alameda Creek about three miles south of Decoto Road, the rapid transit line curves southward away from the railroad to a terminal station in Fremont at Mowry Avenue. The Fremont station is oriented to serve the future urban core as planned in the Fremont General Plan.

The Southern Alameda County Line is 23.0 miles long and contains eight stations.

CONSTRUCTION COSTS

The estimate of construction costs takes into account such significant physical factors as route alignment and grade, type of construction, geological conditions, underpinning requirements, traffic maintenance, utility relocation, and rights of way. It is based on San Francisco Bay Area price levels with allowances to provide for future inflation. Included are all costs necessary for the design and construction of the described system, ready for operation, with the exception of rolling stock, financing charges, and District administrative expenses. The construction costs of the system and the Trans-Bay Tube are summarized in the tables on page 28.

The estimate has been accurately developed to a degree of detail commensurate with the thoroughness of route location and completeness of design information available. Typical designs were prepared for each feature of the work in sufficient detail so that accurate determination of the quantities of materials could be made. Construction methods and procedures utilized on similar work in this and other areas were studied carefully, and the construction methods and cost estimates for major portions of the work were reviewed with recognized consultants.

Special emphasis was placed on determination of rock quality and the extent and location of earth faults in the vicinity of the tunnels; on subsidence problems, Creek Station just north of Ygnacio Valley Road. The station is located generally between Riviera and North California Avenues.

North of the Walnut Creek Station the line passes over North California Avenue on aerial structure to an alignment along the Sacramento-Northern Railroad right of way. After crossing North Main Street the line proceeds on embankment and on grade, except for street separation structures at Parkside Drive and Geary Road. After crossing under Geary Road the line rises and utilizes aerial construction to the Pleasant Hill Station in Walden.

Beyond the Pleasant Hill Station the line descends to grade after crossing over the Southern Pacific tracks. Structures provide for Bancroft and Oak Grove Roads to cross over the rapid transit tracks. The rapid transit tracks are on grade east of the Sacramento-Northern Railroad to San Miguel Road and then ascend to aerial structure and proceed into the Concord Station at Clayton Road. A transit vehicle storage yard is located between the Pleasant Hill and Concord Stations.

The Central Contra Costa Line is 18.9 miles long and includes six stations.

SOUTHERN ALAMEDA COUNTY LINE

(Plates 12-16, pp. 23-27)

The Southern Alameda County Line begins near the Exposition Building and beyond the Fallon Street Station in 8th Street in Oakland. Proceeding southward the subway leaves the alignment of 8th Street, passes beneath the channel of Lake Merritt Inlet, and then follows 7th Street. After passing beneath 5th Avenue, the tracks come to the surface along the east side of the Western Pacific Railroad main line tracks. The rapid transit tracks remain on grade along the railroad until they pass beneath the 19th Avenue overcrossing where they rise on aerial structure and enter the median of East 12th Street. The line continues in this median to Fruitvale Avenue. Both the Fruitvale Avenue Station at 36th Avenue and the transit line southward to 47th Avenue are located immediately east of the Western Pacific tracks.

At 47th Avenue the line crosses the Western Pacific tracks to occupy a narrow strip between the railroad and San Leandro Street. The line continues to follow this strip on aerial structure to 105th Avenue, with a station at 77th Avenue. At 105th Avenue, the structure once again crosses to the east side of the Western Pacific tracks, remaining there to Hayward. The aerial San Leandro Station is located at Davis Street. The line continues on structure through San Leandro, and the next station is located at Hesperian Boulevard. The rapid transit tracks descend to grade to pass under the existing U. S. Highway 50 structure. Aerial construction resumes and continues through Hayward. The Hayward Station is located just north of Jackson Street.

The route crosses to the west of the Western Pacific Railroad immediately south of Jackson Street and parallels the railroad. A station is provided at Alquire Road, and the Union City Station is located at Decoto Road. Storage and maintenance facilities are provided at Decoto Road.

At Alameda Creek about three miles south of Decoto Road, the rapid transit line curves southward away from the railroad to a terminal station in Fremont at Mowry Avenue. The Fremont station is oriented to serve the future urban core as planned in the Fremont General Plan.

The Southern Alameda County Line is 23.0 miles long and contains eight stations.

CONSTRUCTION COSTS

The estimate of construction costs takes into account such significant physical factors as route alignment and grade, type of construction, geological conditions, underpinning requirements, traffic maintenance, utility relocation, and rights of way. It is based on San Francisco Bay Area price levels with allowances to provide for future inflation. Included are all costs necessary for the design and construction of the described system, ready for operation, with the exception of rolling stock, financing charges, and District administrative expenses. The construction costs of the system and the Trans-Bay Tube are summarized in the tables on page 28.

The estimate has been accurately developed to a degree of detail commensurate with the thoroughness of route location and completeness of design information available. Typical designs were prepared for each feature of the work in sufficient detail so that accurate determination of the quantities of materials could be made. Construction methods and procedures utilized on similar work in this and other areas were studied carefully, and the construction methods and cost estimates for major portions of the work were reviewed with recognized consultants.

Special emphasis was placed on determination of rock quality and the extent and location of earth faults in the vicinity of the tunnels; on subsidence problems,

PLATE 14, SOUTHERN ALAMEDA COUNTY LINE (HAYWARD), SEE TEXT P. 24

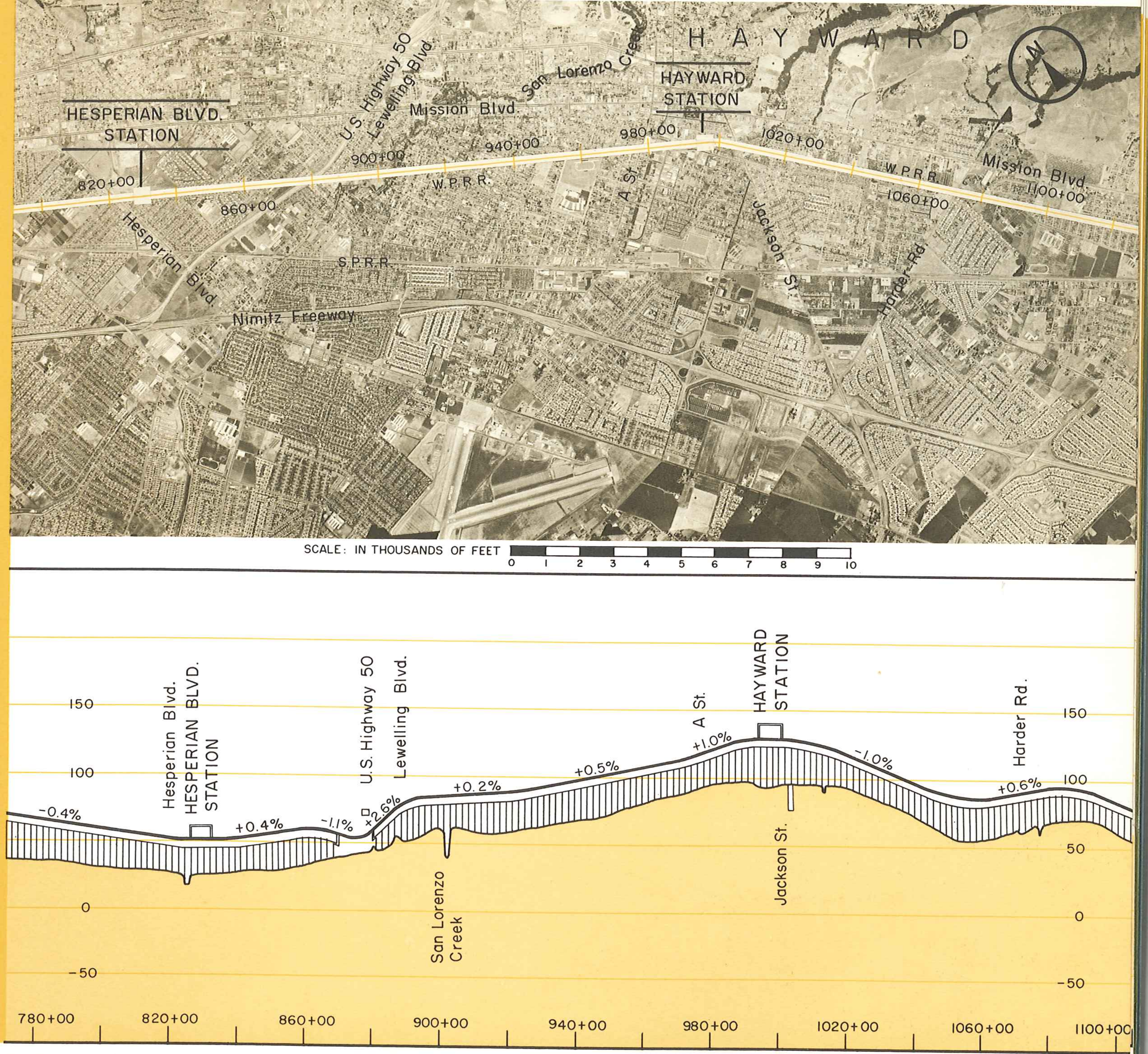
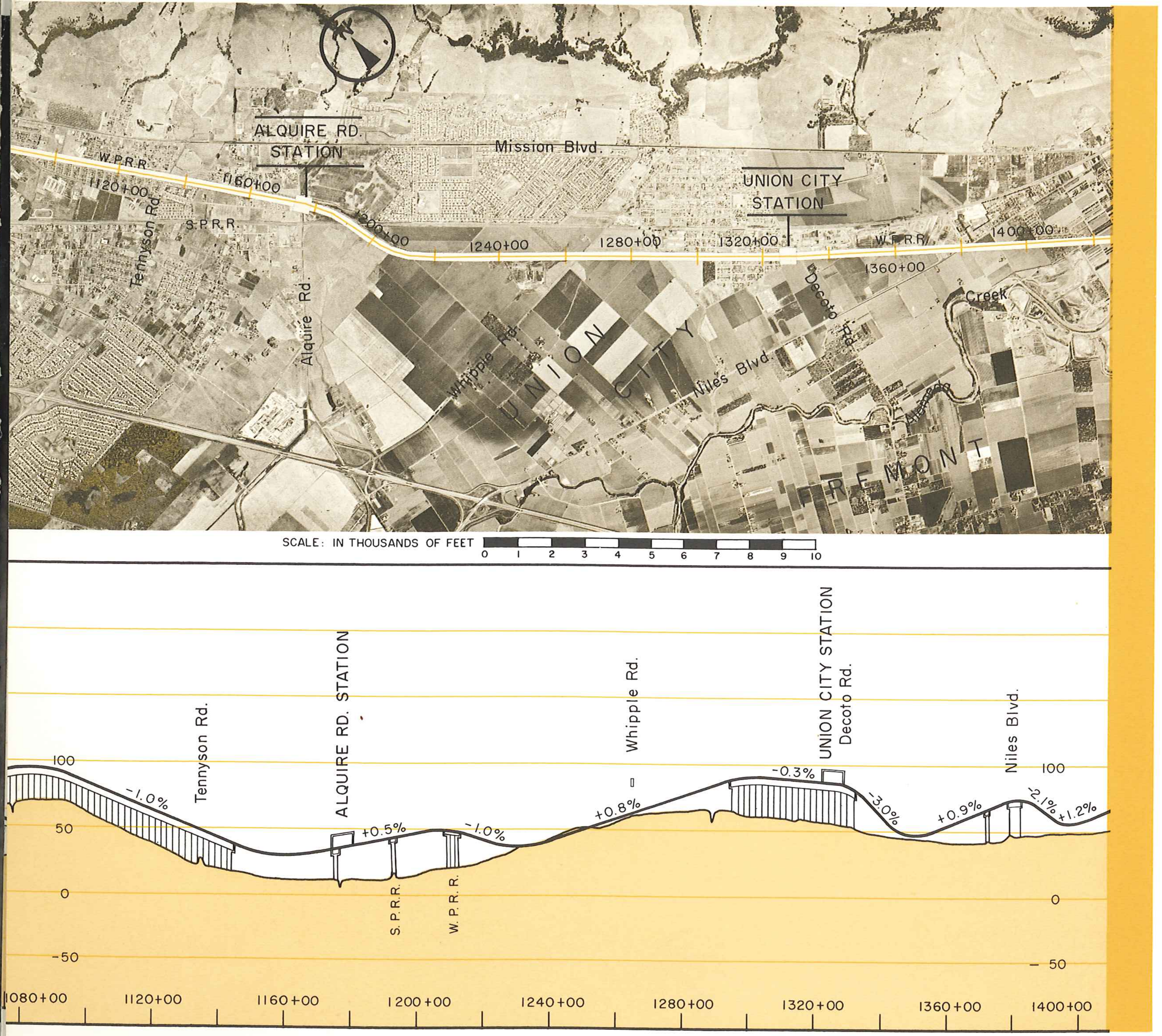


PLATE 15, SOUTHERN ALAMEDA COUNTY LINE (UNION CITY), SEE TEXT P. 24



ground water, and soil conditions to be encountered; and on the materials composing the Bay bottom along the route of the tube. Investigation was accomplished through actual field inspection by engineering geologists, supplemented by review of geological maps, engineering reports, and past experience, as well as by core borings in the bottom of the Bay.

The estimated costs associated with the need for underpinning of adjacent structures during the construction period were established by enlisting the cooperation of local engineers and architects in furnishing foundation plans of typical important existing structures along the subway routes.

In order to develop the costs for utility relocation, the respective utility organizations were consulted to determine the extent of interference that might be anticipated. In some cases estimates were developed for this work by the controlling agency.

The estimated costs of acquisition of necessary rights of way were established by local specialists experienced in the appraisal of property and familiar with local trends of real estate values.

The construction estimate reflects wage rates and material prices in effect in the San Francisco Bay Area at the end of the first quarter of 1960, the date when the basic estimates were prepared. Careful review of cost trends in heavy construction in California and throughout the nation during the period 1950-1962 indicates that inflation has substantially increased construction costs over the years. Allowance to compensate for cost increases actually realized since 1960 and for a probable continuing inflationary trend during the major portion of the construction period required for this project was considered a necessary part of the estimate. Accordingly an amount of approximately 153 million dollars was provided in the estimate for the system and the Trans-Bay Tube. This provides at least five per cent for the inflation actually experienced since the basic estimates were prepared and about fifteen per cent for a future allowance.

The cost of the rapid transit system, including the Trans-Bay Tube and its approaches, is divided into the cost items in the summary tables. The elements included in each item are as follows:

Track and Structures. Costs to construct the transit structures between stations, including all related costs, such as track work, site preparation, street widening and restoration, fencing, traffic maintenance during the construction period, grade separation structures, and protection of existing buildings.

Stations. Costs of all station construction as well as the track structure within the station, the parking and access area construction, and the fare collection system. Related costs are identical with those listed above under "Track and Structures."

Yards and Shops. Costs for transit yard facilities; service, inspection, and routine maintenance buildings and equipment; track work within the yard limits and lead tracks; and other components incident to the storage, maintenance and repair of transit rolling stock and equipment. The cost of the administration and operations center is included in this item.

Electrification. Costs of the electrical system to furnish power for train propulsion and control, including such items as utility connections, sub-stations, the third rail for train power, and incidental electrical facilities.

Train Control. All costs of the automatic train control system.

Utility Relocation. All costs incidental to the relocation and maintenance of utility installations necessitated by construction of the transit system. Electric power distribution, communication, gas, water, steam, sewage and storm drainage are affected.

Engineering and Charges. These costs include fees for architectural and engineering services as well as construction management costs during the construction period. Interest during construction, operating expenses, financing charges, and District administrative expenses are not included.

Right of Way. All costs relative to the acquisition of property required for the construction of the transit system as well as for the demolition of existing improvements, the cost of title investigations, appraisals and negotiating and legal expenses incident to the right of way acquisition.

Contingencies. A contingency is included amounting to ten per cent of the sum of all construction costs including engineering and charges and right of way.

Inflation. This cost is an allowance to cover realized and anticipated increases in construction costs over the first quarter 1960 price levels used in preparing the estimate.

Pre-Operating Expenses. Before formal revenue operation can begin over any completed segment of the rapid transit system, it will be necessary to plan operations, recruit and train personnel, and perform other preparatory functions. These pre-operating expenses are in addition to the capital cost of construction of the system, and they are estimated at a cost of $7,000,000. The total of the capital cost of construction and the pre-operating expense is $790,493,000, and it is this

ground water, and soil conditions to be encountered; and on the materials composing the Bay bottom along the route of the tube. Investigation was accomplished through actual field inspection by engineering geologists, supplemented by review of geological maps, engineering reports, and past experience, as well as by core borings in the bottom of the Bay.

The estimated costs associated with the need for underpinning of adjacent structures during the construction period were established by enlisting the cooperation of local engineers and architects in furnishing foundation plans of typical important existing structures along the subway routes.

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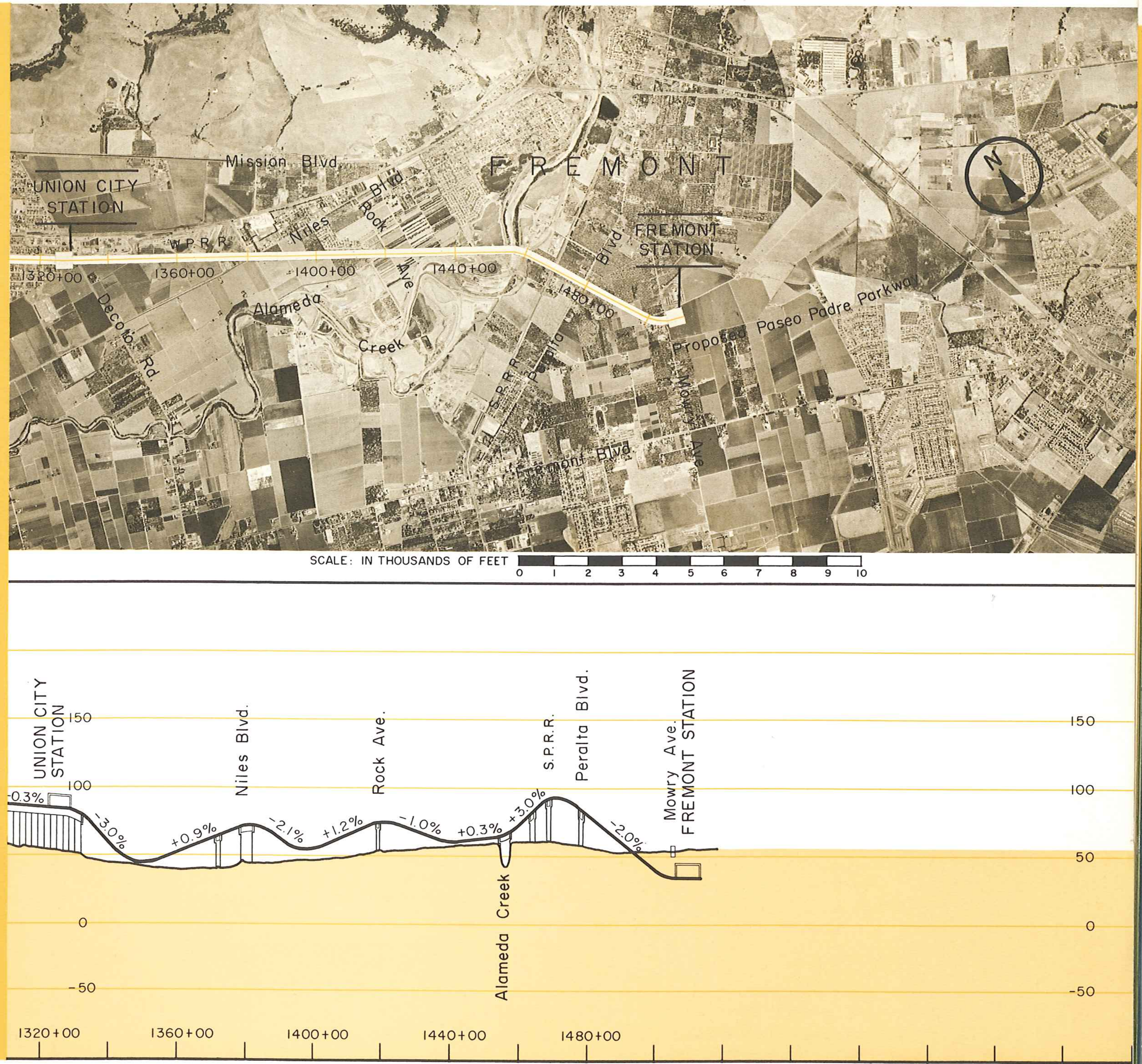
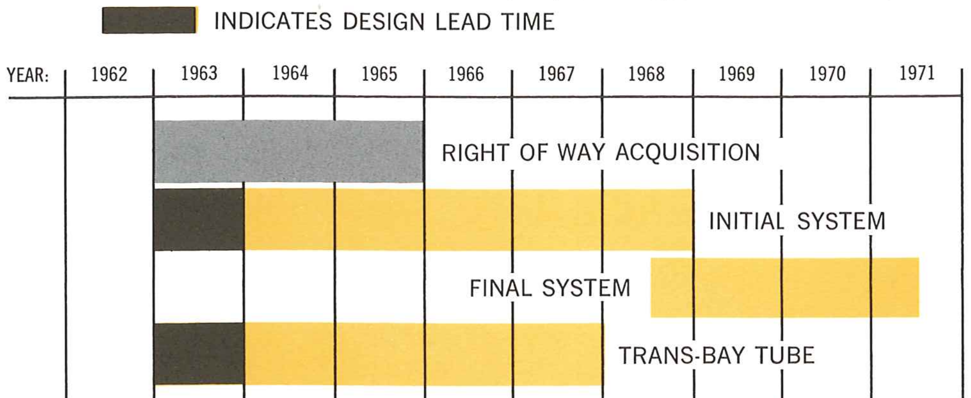
Inflation. This cost is an allowance to cover realized and anticipated increases in construction costs over the first quarter 1960 price levels used in preparing the estimate.

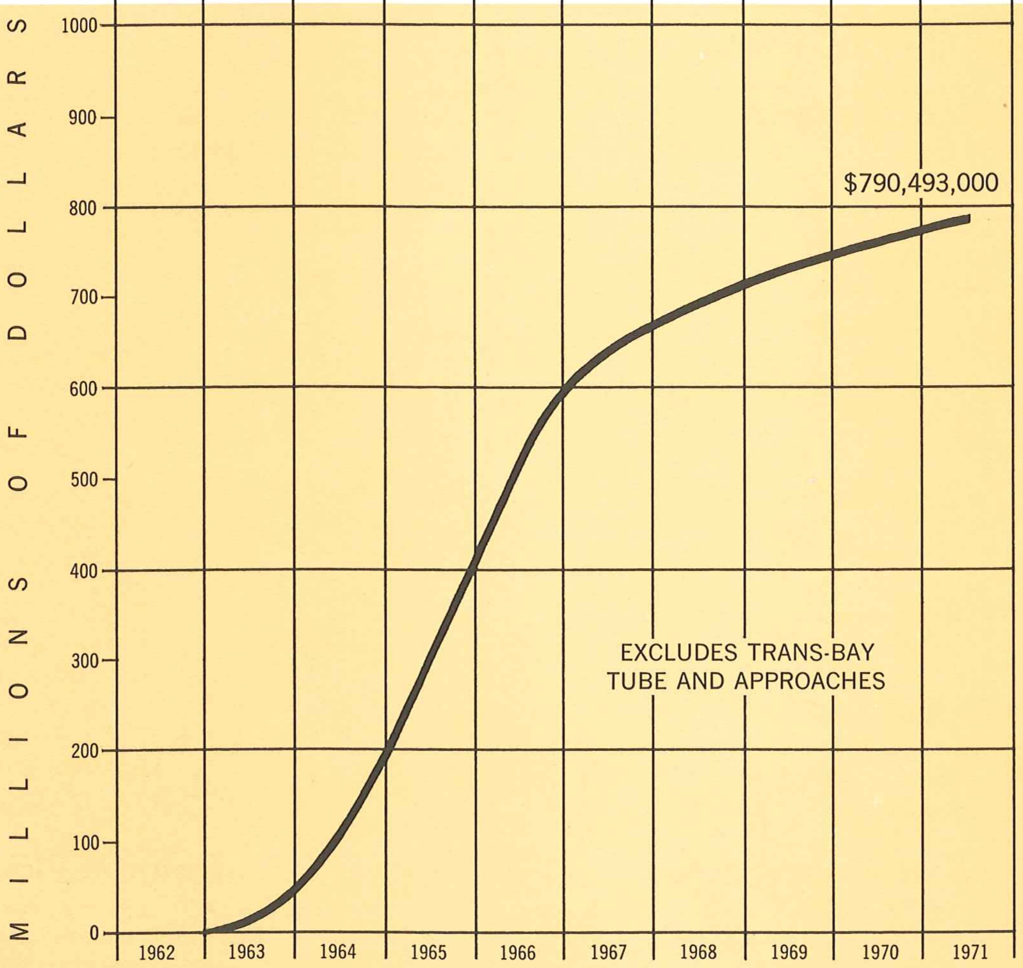
Pre-Operating Expenses. Before formal revenue operation can begin over any completed segment of the rapid transit system, it will be necessary to plan operations, recruit and train personnel, and perform other preparatory functions. These pre-operating expenses are in addition to the capital cost of construction of the system, and they are estimated at a cost of $7,000,000. The total of the capital cost of construction and the pre-operating expense is $790,493,000, and it is this

PLATE 16, SOUTHERN ALAMEDA COUNTY LINE (FREMONT), SEE TEXT P. 24



CONSTRUCTION SCHEDULE





DRAWDOWN OF FUNDS

the system will be opened to service as completed. One segment of route must be available early for use in testing the equipment and control system and for training personnel.

Although the Trans-Bay Tube is to be financed and built by the California Toll Bridge Authority, the construction of the tube and the remainder of the system must be closely coordinated. Engineering design on the tube should begin concurrently with that for the initial parts of the rapid transit system. Actual construction requires four years and should be completed by January 1, 1968.

Relating the estimated capital cost of the system, including the pre-operating expenses, with the construction schedule and applying a reasonable rate of expenditure for each of the components, the drawdown of funds was established. Shown on page 35 are detailed tabulations of the estimated drawdown of funds.

PATRONAGE

Estimates of patronage are the basis for a forecast of rapid transit revenue, operating expense, and requirements for rolling stock. The forecast of traffic volumes which will be attracted to the proposed rapid transit system is a key element in economic studies of the system. In addition, detailed patronage estimates define some of the parameters in physical features and service to be provided, thus serving as a control against excess or deficiency in design. An extensive documentation of past and present Bay Area travel characteristics was the foundation for patronage studies.

BAY AREA TRAFFIC STUDIES. The origin-destination survey is the tool for measuring traffic volumes and patterns. This involved division of the Bay Area into a number of logically defined traffic zones and the measurement of traffic volumes within, among and through these zones by origin, destination, time of day, mode of travel, and purpose of trip. The principal surveys available include one conducted throughout the Bay region in 1954 for the San Francisco Bay Area Rapid Transit Commission and another, the Bay Area Metropolitan Traffic Survey, conducted by federal, state, and local highway agencies in 1946-1947.

Both of these studies were updated to the 1959 level in terms of annual average weekday traffic. The 1954 survey was updated by means of transit and auto growth factors developed from actual change in traffic volumes, as measured at nine cordon lines strategically placed so as to intercept all major highway and transit movements of significance in rapid transit planning.

The internal auto person-trips in the 1946-1947 survey were updated by means of analysis which measured changes in motor vehicle registration within each traffic zone as well as changes in motor vehicle usage and average auto occupancy. Zones of heavy retail and industrial concentration were specially treated. Internal transit person-trip volumes were updated by analysis of the traffic records for individual transit routes.

TRAFFIC PROJECTION. Once accurate travel movement of people for 1959 was determined, it was necessary to predict future volumes and patterns. The year 1975 was selected as a time base for forecasting traffic movements between regional cordon areas. Two separate methods were used in obtaining the final projection factors for rapid transit traffic. The first method utilized a special analysis to provide a measurement o the attraction and the generation of trips betwee areas, considering pertinent factors such as jobs, residential population, auto registration, and travel time This step yielded separate predictions of commut trips and those trips made for other purposes on a annual average weekday in 1975.

The second method used to forecast 1975 traffi was a projection of 1959-level data by means of a comprehensive series of factors derived primarily from th statistical extrapolation of present trends. The tw analyses were conjoined and used to develop the fina projection factors employed for forecasting rapid transit traffic.

DIVERSION RESEARCH. The many unique features o the proposed Bay Area rapid transit system, such as it high speed, frequent service, long average length o trip, and regional character, indicated the necessity fo careful study of the numerous factors influencing traffic distribution between highway and transit facilitie An extensive investigation was made of these facto making use of the origin-destination, population, vehicle registration, personal income, travel time, cos distance, and other data available in the project are Study was concentrated, among other sources, on available field data from the 1954 origin-destination surve Where relatively high volumes of interurban passenger traffic were served by a balanced combination rail commute lines, bus routes, and highway facilitie analysis identified and permitted evaluation of sever factors of significance in estimating rapid transit utilization.

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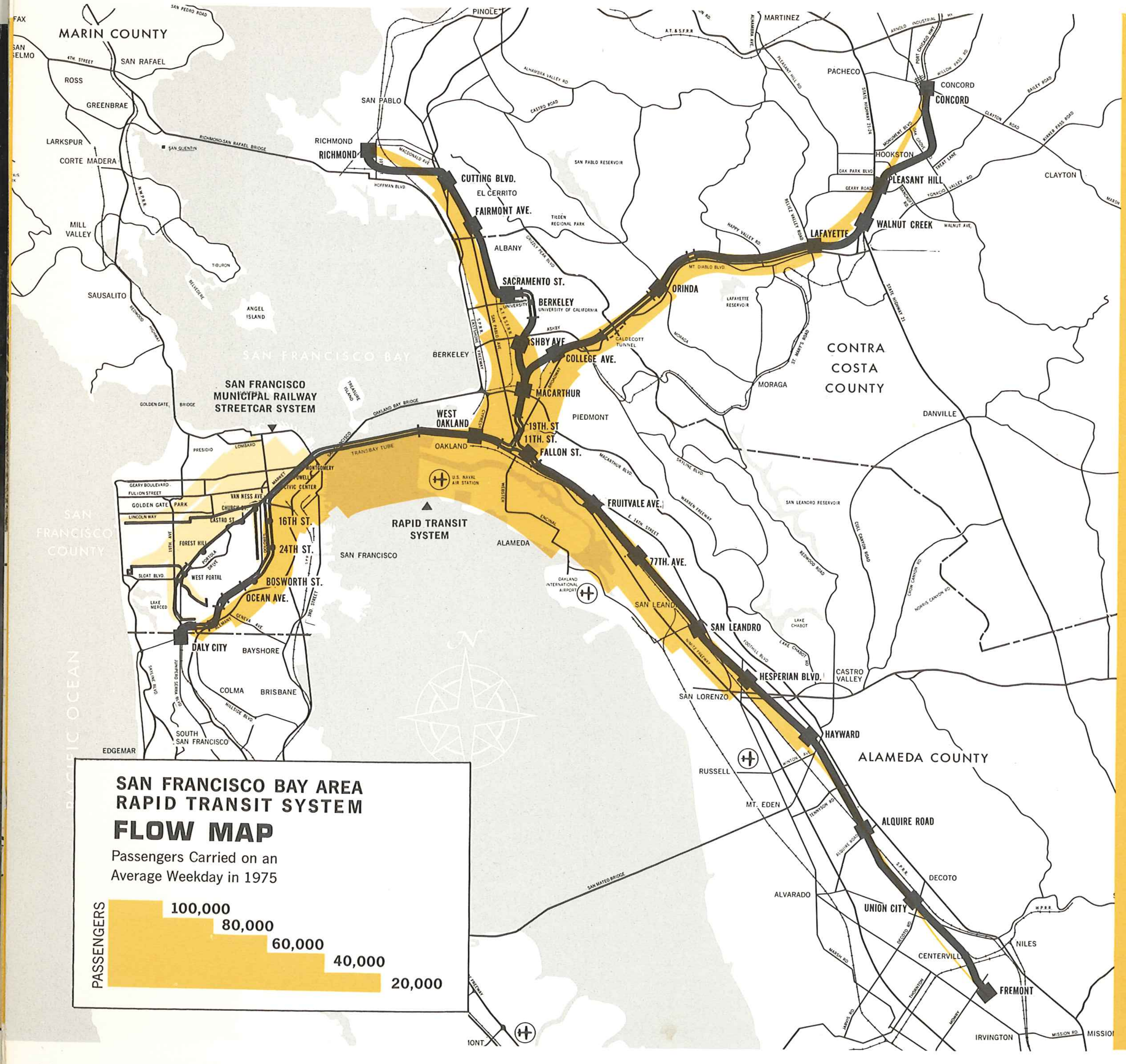
DIVERSION RESEARCH. The many unique features of the proposed Bay Area rapid transit system, such as its high speed, frequent service, long average length of trip, and regional character, indicated the necessity for careful study of the numerous factors influencing traffic distribution between highway and transit facilities. An extensive investigation was made of these factors making use of the origin-destination, population, vehicle registration, personal income, travel time, cost, distance, and other data available in the project area. Study was concentrated, among other sources, on available field data from the 1954 origin-destination survey. Where relatively high volumes of interurban passenger traffic were served by a balanced combination of rail commute lines, bus routes, and highway facilities, analysis identified and permitted evaluation of several factors of significance in estimating rapid transit utilization.

Of principal importance were whether the travel occurs during peak periods in the peak direction, whether the trip is between home and work or for

TYPICAL FARES BETWEEN SELECTED STATIONS

	DALY CITY	OCEAN AVENUE	24th STREET	CIVIC CENTER	POWELL STREET	MONTGOMERY STREET	11th STREET	19th STREET	MacARTHUR	ORINDA	WALNUT CREEK	CONCORD	FREMONT	HAYWARD	SAN LEANDRO	FRUITVALE	FALLON STREET	BERKELEY	FAIRMONT AVENUE
OCEAN AVENUE	$0.25																		
24th STREET	0.25	$0.25																	
CIVIC CENTER	0.25	0.25	$0.25																
POWELL STREET	0.25	0.25	0.25	$0.25															
MONTGOMERY STREET	0.25	0.25	0.25	0.25	$0.25														
11th STREET	0.55	0.50	0.40	0.40	0.35	$0.35													
19th STREET	0.55	0.50	0.45	0.40	0.35	0.35	$0.25												
MacARTHUR	0.55	0.55	0.45	0.45	0.40	0.40	0.25	$0.25											
ORINDA	0.70	0.65	0.60	0.55	0.55	0.55	0.25	0.25	$0.25										
WALNUT CREEK	0.80	0.80	0.75	0.70	0.70	0.70	0.45	0.40	0.40	$0.25									
CONCORD	0.95	0.90	0.85	0.80	0.80	0.80	0.55	0.55	0.50	0.40	$0.25								
FREMONT	1.00	0.95	0.90	0.85	0.85	0.85	0.60	0.60	0.65	0.75	0.90	$1.00							
HAYWARD	0.80	0.75	0.70	0.65	0.65	0.65	0.40	0.40	0.45	0.55	0.70	0.80	$0.30						
SAN LEANDRO	0.70	0.65	0.60	0.55	0.55	0.55	0.25	0.30	0.35	0.45	0.60	0.70	0.45	$0.25					
FRUITVALE	0.60	0.55	0.50	0.45	0.45	0.45	0.25	0.25	0.25	0.35	0.50	0.60	0.50	0.35	$0.25				
FALLON STREET	0.60	0.50	0.45	0.40	0.35	0.35	0.25	0.25	0.25	0.30	0.45	0.55	0.60	0.40	0.25	$0.25			
BERKELEY	0.60	0.60	0.55	0.50	0.50	0.50	0.25	0.25	0.25	0.30	0.45	0.55	0.70	0.50	0.40	0.25	$0.25		
FAIRMONT AVENUE	0.70	0.65	0.60	0.55	0.55	0.55	0.25	0.25	0.25	0.40	0.50	0.60	0.75	0.55	0.45	0.35	0.30	$0.25	
RICHMOND	0.80	0.75	0.70	0.65	0.65	0.65	0.40	0.40	0.35	0.45	0.60	0.70	0.85	0.65	0.55	0.45	0.40	0.25	$0.25



SAN FRANCISCO BAY AREA RAPID TRANSIT SYSTEM

FLOW MAP

Passengers Carried on an Average Weekday in 1975

some other purpose, and whether the trip is to or from a major business district. For each category of potential rapid transit trip, the ratio of door-to-door travel time by rapid transit to door-to-door travel time by automobile was determined to be the best measurement of propensity to use rapid transit.

A series of time-ratio diversion curves were developed for all regional traffic of potential interest to rapid transit; for peak-period, peak-direction work trips having one or both trip terminals in downtown San Francisco or Oakland; for similar trips having neither trip terminal in downtown San Francisco or Oakland; and for all other trips, separately with and without trip terminals in downtown San Francisco or Oakland. For internal San Francisco and internal East Bay traffic, two additional time-ratio curves, differentiating between downtown and non-downtown trips, were developed.

Rapid Transit Patronage. Once route selection studies had determined the location of rapid transit lines and stations, it was possible to define trips of interest to rapid transit. These are trips of sufficient length and with origins and destinations in suitable proximity and geographic orientation to rapid transit lines so as to be susceptible to diversion to rapid transit. Door-to-door peak and off-peak travel times for each trip by rapid transit and by automobile were calculated, using the expanded network of freeways, arterials, and local streets assumed to be available during the years for which patronage estimates were to be prepared. Ratios of travel time via rapid transit to travel time by automobile were then computed, and by application of the diversion curves, rapid transit passenger volumes were estimated.

The intra-San Francisco and inner East Bay estimates of patronage and revenue were adjusted to allow for the effect of the higher cost of a combined streetcar-rapid transit trip or bus-rapid transit trip compared to the cost for a streetcar or bus trip today.

The flow map on this page depicts the resulting rapid transit traffic for an average weekday in 1975. Annual patronage estimates for the years of the forecast, 1969 through 1980, are presented in the tabulation on page 34.

General Assumptions. The estimates of patronage and those of revenue, operating expense, and requirements for rolling stock are based upon certain general assumptions as follows:

1. The same general trends of economic activity and business conditions experienced during the past five years in the Bay Area will continue throughout the period of the estimate.
2. Adequate access and parking areas will be provided for patrons at rapid transit stations. These facilities are included in this plan and in the estimates of construction cost.
3. Other transit service in the Bay Area will be coordinated with regional rapid transit in order to secure re-routing, where feasible, of existing inter-urban and local transit operations to act as feeders to the regional rapid transit system.
4. The San Francisco Bay Area Rapid Transit District will retain essentially the same powers delegated to it by existing law to establish fares, concession rates and fees.
5. There will be no legislation adversely affecting the use, operation, condition, or financial obligations of the San Francisco Bay Area Rapid Transit District or the rapid transit system.
6. The rates of toll charged for vehicular passage across San Francisco Bay will not be reduced to an extent that will significantly prejudice the relative attraction of rapid transit compared to the private automobile.
7. Highway planning for the Bay Area will be complementary to and not detractive of the functions of the rapid transit system.
8. An appropriate policy of advertising and public education will be followed by the District to encourage rapid transit patronage.

FARES AND REVENUE

A schedule of proposed station-to-station rapid transit fares was developed. Of prime significance is the necessity that rapid transit fare levels be equated to the cost of other travel modes, principally the automobile. This entailed a thorough investigation of typical auto travel out-of-pocket costs, including the effects of auto occupancy, bridge tolls, parking fees, and the costs of gasoline, oil, and normal tire wear. In addition, existing commute and cash transit fares were taken into consideration. In determining comparable rapid transit travel costs, the costs of any necessary increments of feeder travel were included.

It was found desirable and feasible to employ a fare structure based on distance travelled, rather than on the usual flat-fare or zone-fare types of tariff. A specific fare thus results for each station-to-station trip. The rate schedule provides a minimum fare of 25 cents for any trip up to eight miles, with a gradual decline in cost per mile as distance travelled increases, vary-some other purpose, and whether the trip is to or from a major business district. For each category of potential rapid transit trip, the ratio of door-to-door travel time by rapid transit to door-to-door travel time by automobile was determined to be the best measurement of propensity to use rapid transit.

A series of time-ratio diversion curves were developed for all regional traffic of potential interest to rapid transit; for peak-period, peak-direction work trips having one or both trip terminals in downtown San Francisco or Oakland; for similar trips having neither trip terminal in downtown San Francisco or Oakland; and for all other trips, separately with and without trip terminals in downtown San Francisco or Oakland. For internal San Francisco and internal East Bay traffic, two additional time-ratio curves, differentiating between downtown and non-downtown trips, were developed.

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2. Adequate access and parking areas will be provided for patrons at rapid transit stations. These facilities are included in this plan and in the estimates of construction cost.
3. Other transit service in the Bay Area will be coordinated with regional rapid transit in order to secure re-routing, where feasible, of existing interurban and local transit operations to act as feeders to the regional rapid transit system.
4. The San Francisco Bay Area Rapid Transit District will retain essentially the same powers delegated to it by existing law to establish fares, concession rates and fees.
5. There will be no legislation adversely affecting the use, operation, condition, or financial obligations of the San Francisco Bay Area Rapid Transit District or the rapid transit system.
6. The rates of toll charged for vehicular passage across San Francisco Bay will not be reduced to an extent that will significantly prejudice the relative attraction of rapid transit compared to the private automobile.
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FARES AND REVENUE

A schedule of proposed station-to-station rapid transit fares was developed. Of prime significance is the necessity that rapid transit fare levels be equated to the cost of other travel modes, principally the automobile. This entailed a thorough investigation of typical auto travel out-of-pocket costs, including the effects of auto occupancy, bridge tolls, parking fees, and the costs of gasoline, oil, and normal tire wear. In addition, existing commute and cash transit fares were taken into consideration. In determining comparable rapid transit travel costs, the costs of any necessary increments of feeder travel were included.

It was found desirable and feasible to employ a fare structure based on distance travelled, rather than on the usual flat-fare or zone-fare types of tariff. A specific fare thus results for each station-to-station trip. The rate schedule provides a minimum fare of 25 cents for any trip up to eight miles, with a gradual decline in cost per mile as distance travelled increases, varying between 3.2 cents per mile at eight miles to 2.25 cents per mile for the longest trips. An additional 10 cents is added to the fare for trips that involve crossing San Francisco Bay. Typical station-to-station fares are illustrated in the table on page 31.

Fare revenue was estimated by multiplication of the projected rapid transit passenger volumes for each station-to-station movement times the fare for that movement. Investigation of additional potential sources of revenue resulted in an estimate of about one per cent of fare revenue as income from advertising and concessions. Total estimated revenue for the years of forecast 1969 through 1980 is tabulated on page 34.

OPERATIONS

The proposed route network and the estimates of rapid transit patronage were the bases for estimating daily train operations. The way in which lines and train service should be interconnected was developed, resulting in a physical track framework within which all major traffic movements between lines are directly accommodated. Trains are not, however, able to travel directly between the Central Contra Costa Line and the Berkeley-Richmond Line.

Patterns of service are expected to vary through the day, and accordingly, schedules of train operations were prepared. These provided the basis for determining a large part of rapid transit operating expense, including costs of traction power, train attendants, rolling stock maintenance, and other items. Scheduling analysis also furnished an actual count of rolling stock requirements and the car storage space needed as well as a test of the adequacy of track capacities at critical sections.

Using plans of the proposed routes, performance data for the prototype rapid transit car, and the stop-intervals at each station, running times for the entire system were calculated. These are shown in the adjacent table. Working timetables were then constructed taking into account all necessary practical considerations, such as minimum safe headway between trains, time needed for switching in yards, the minimum time required for reversing trains at turnback points, layover time requirements for attendants, and the like.

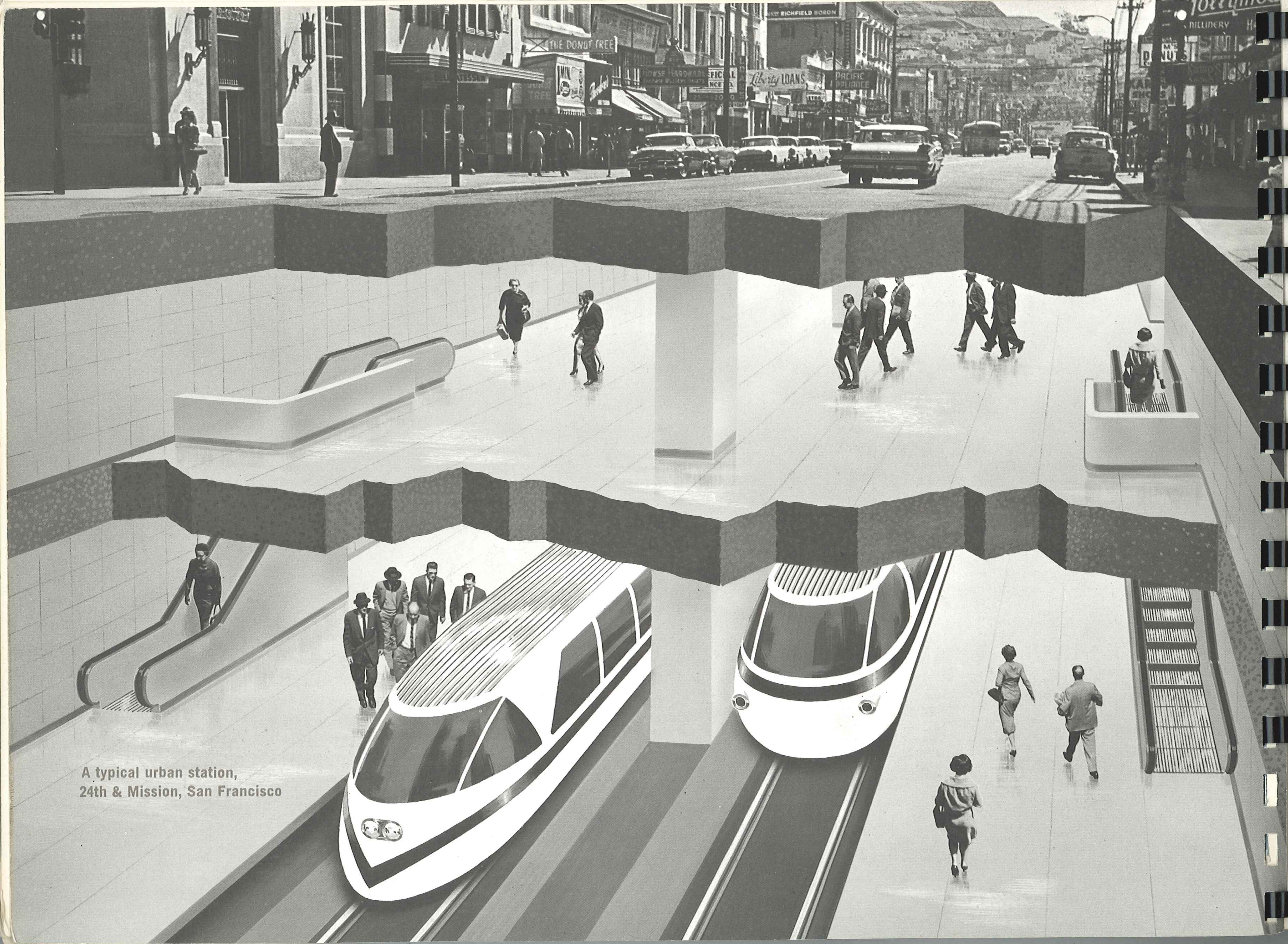
Analysis of the completed working timetables allowed estimation of daily car-miles operated, the maximum number of cars in each yard at any one time, and other data pertinent to operating expense estimates. The number of employees required and their working hours and wages were determined by pro

PEAK-HOUR TRAIN TRAVEL TIMES

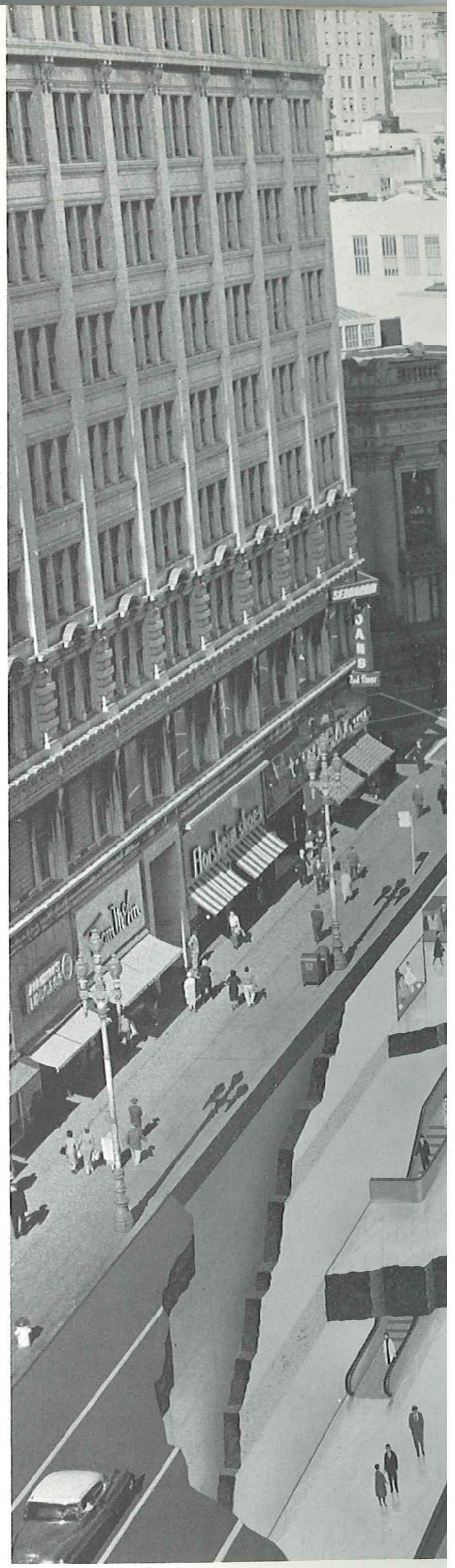
	Minutes	
Line and Station	*Between Stations*	*From First Station*
MISSION – TRANS-BAY – CENTRAL CONTRA COSTA LINES		
Daly City	–	–
Ocean Ave. (San Francisco)	2	2
Bosworth St. (San Francisco)	2	4
24th St. (San Francisco)	2	6
16th St. (San Francisco)	2	8
Civic Center (San Francisco)	2	10
Powell St. (San Francisco)	1	11
Montgomery St. (San Francisco)	1	12
West Oakland	6	18
11th St. (Oakland)	2	20
19th St. (Oakland)	1	21
MacArthur (Oakland)	2	23
College Ave. (Oakland)	3	26
Orinda	4	30
Lafayette	6	36
Walnut Creek	2	38
Pleasant Hill	3	41
Concord	4	45
SOUTHERN ALAMEDA COUNTY – BERKELEY - RICHMOND LINES		
Fremont	–	–
Union City	3	3
Alquire Road (Hayward)	3	6
Hayward	4	10
Hesperian Blvd. (San Lorenzo)	4	14
San Leandro	3	17
77th Ave. (Oakland)	3	20
Fruitvale Ave. (Oakland)	3	23
Fallon St. (Oakland)	3	26
11th St. (Oakland)	1	27
19th St. (Oakland)	1	28
MacArthur (Oakland)	2	30
Ashby Ave. (Berkeley)	3	33
Berkeley	2	35
Sacramento St. (Berkeley)	2	37
Fairmont Ave. (El Cerrito)	2	39
Cutting Blvd. (El Cerrito)	3	42
Richmond	3	45

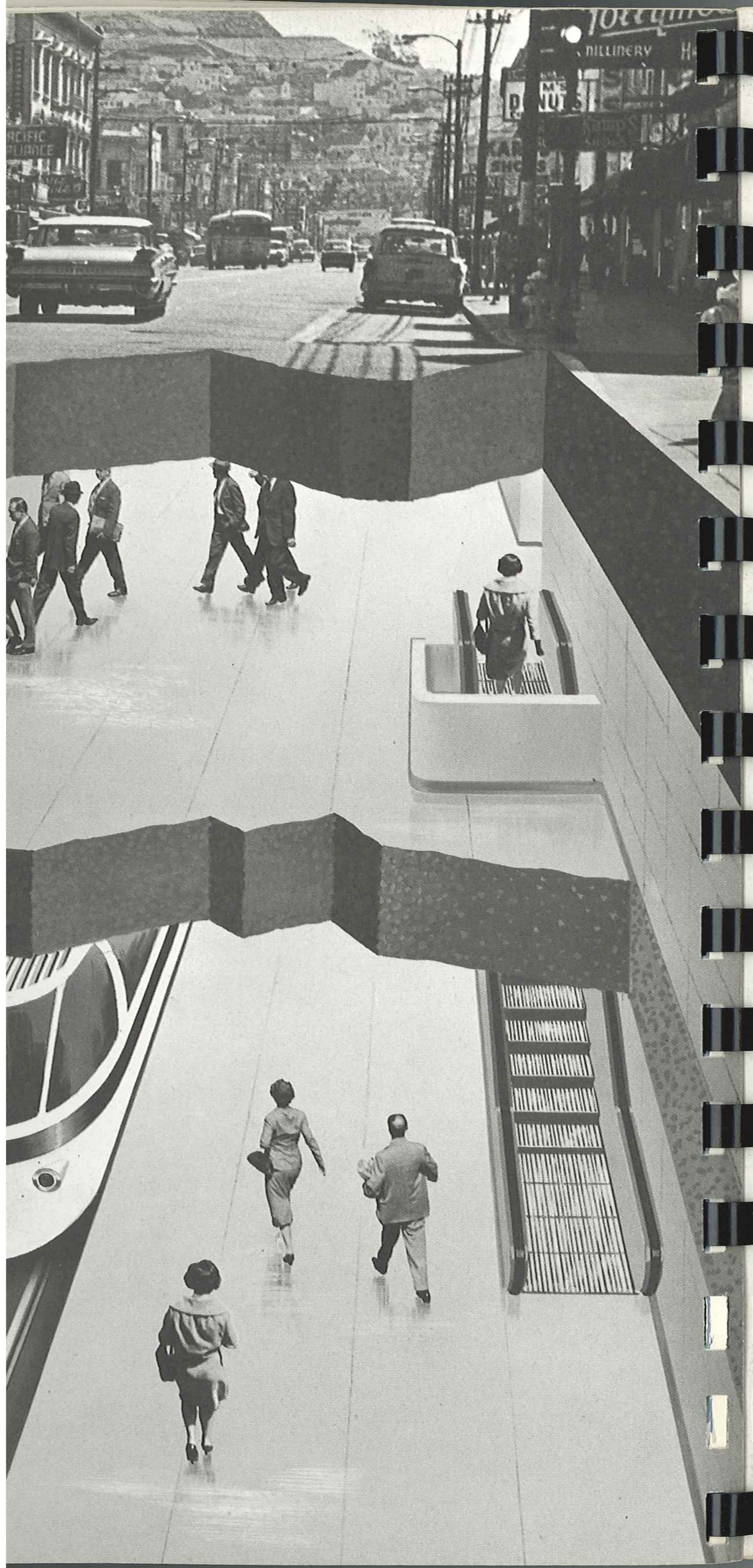
THE LOOK OF RAPID TRANSIT

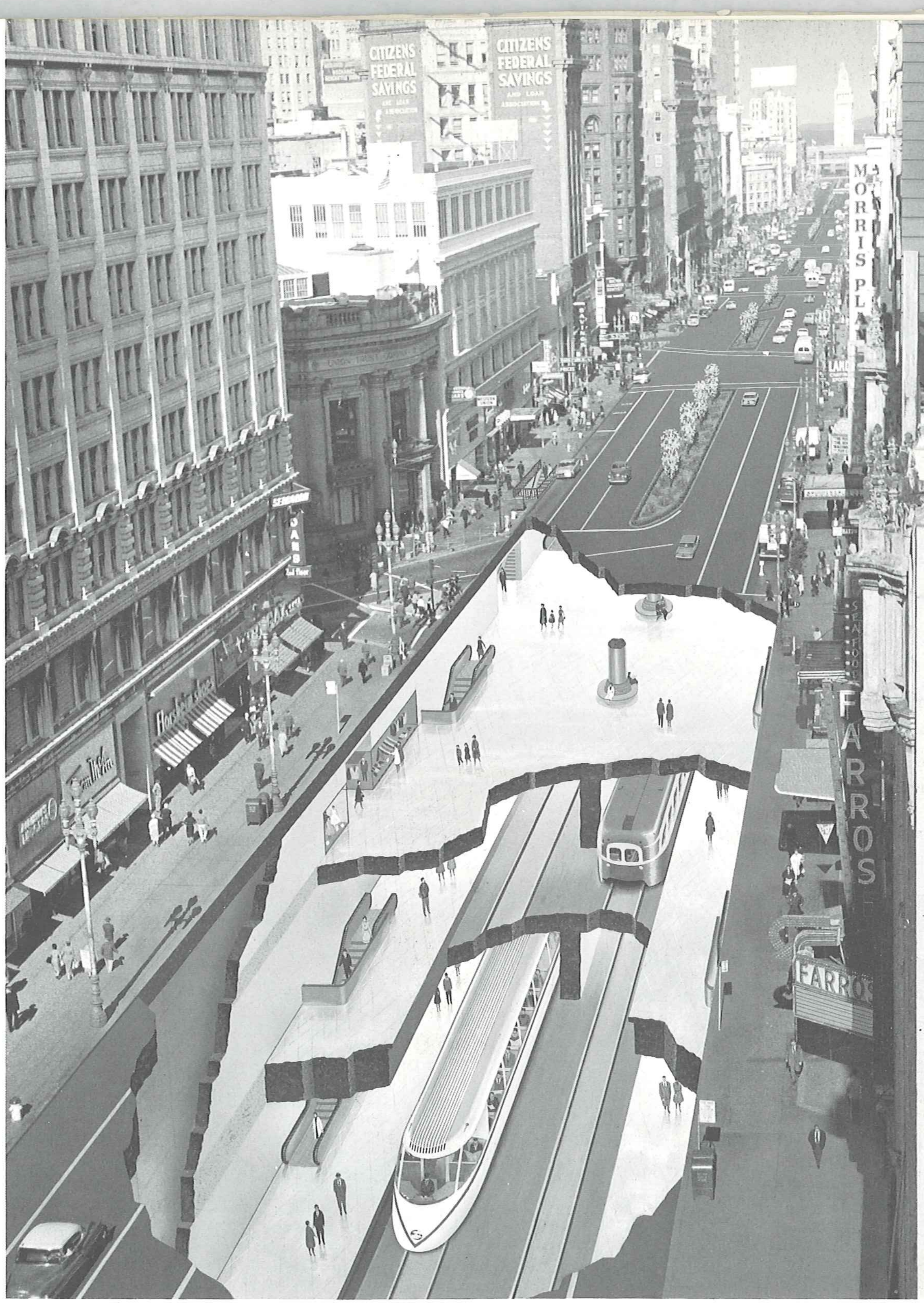
A Selection of Photo-Renderings Typical of the Proposed Bay Area Rapid Transit System

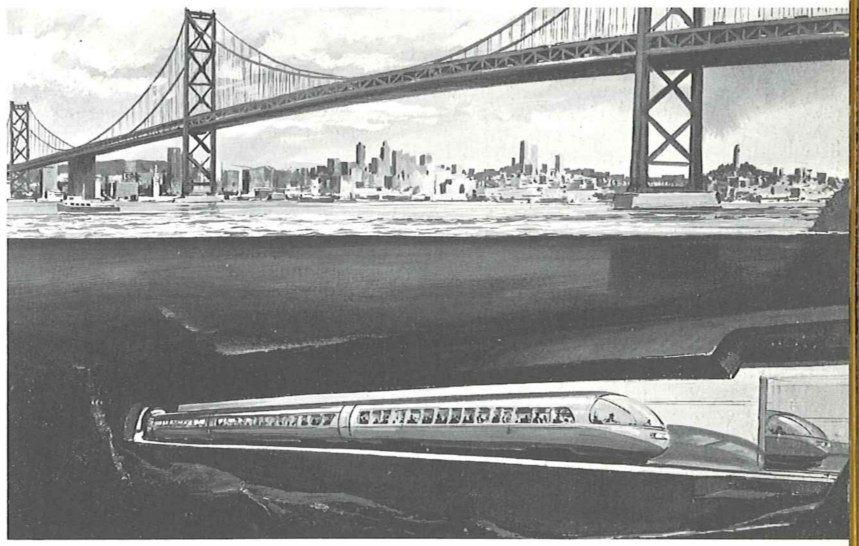


A typical urban station,
24th & Mission, San Francisco





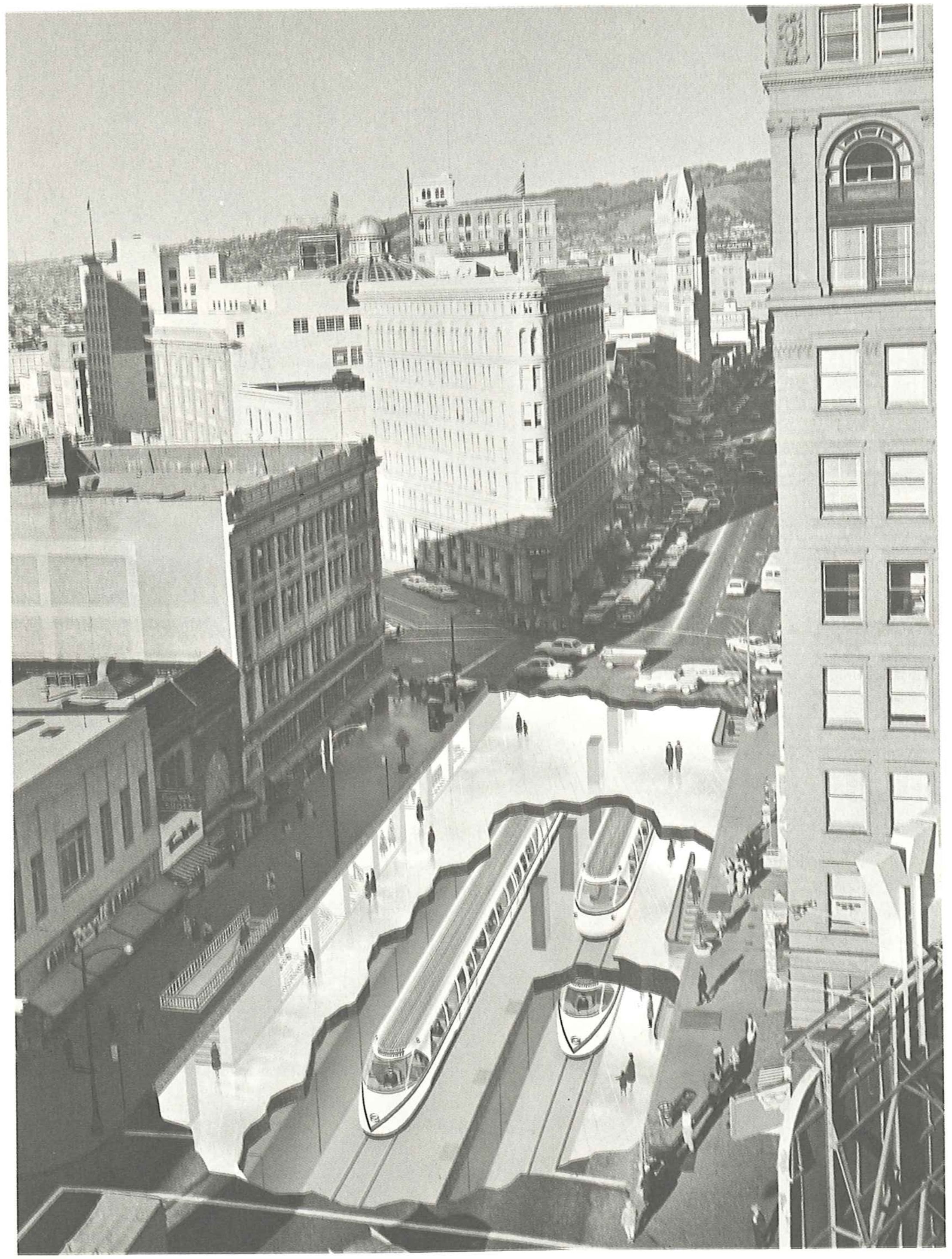


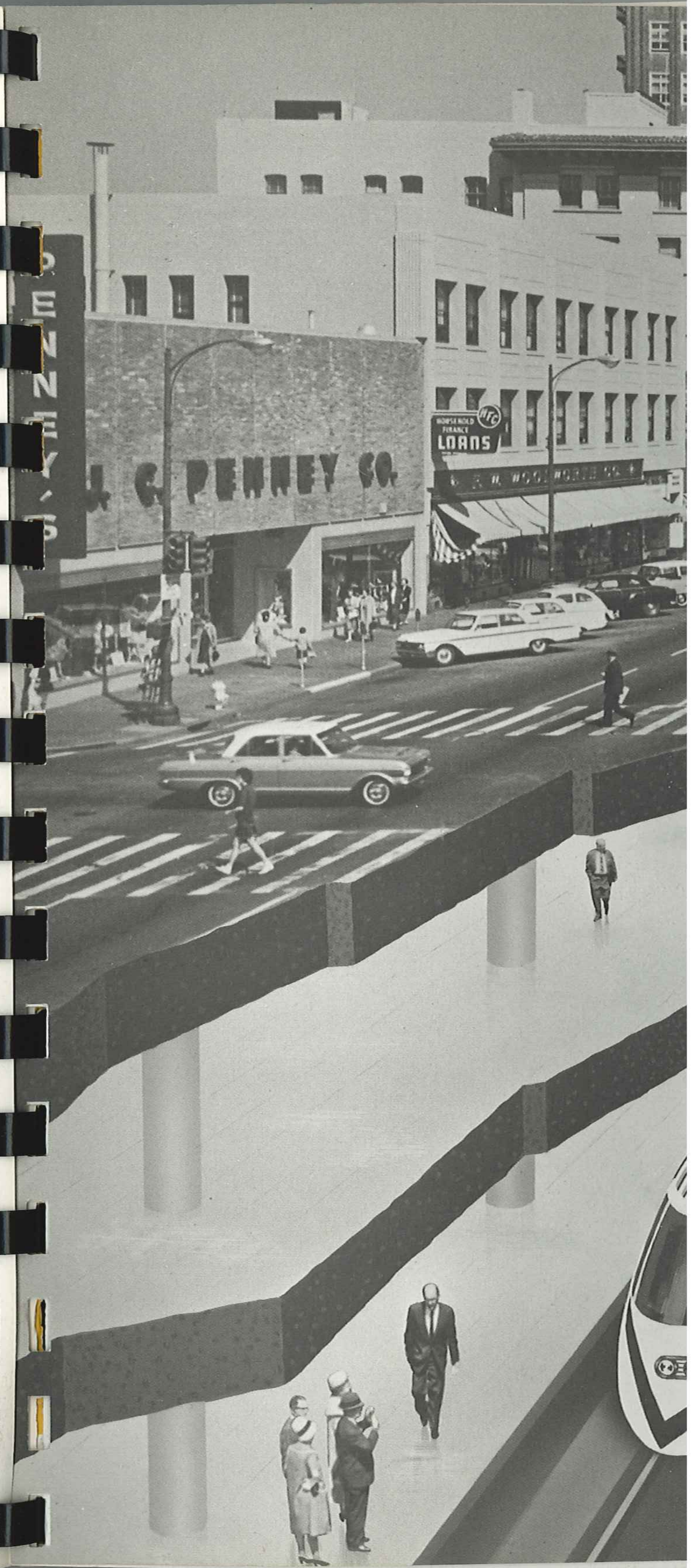


The Trans-Bay Tube, linking East Bay and West Bay

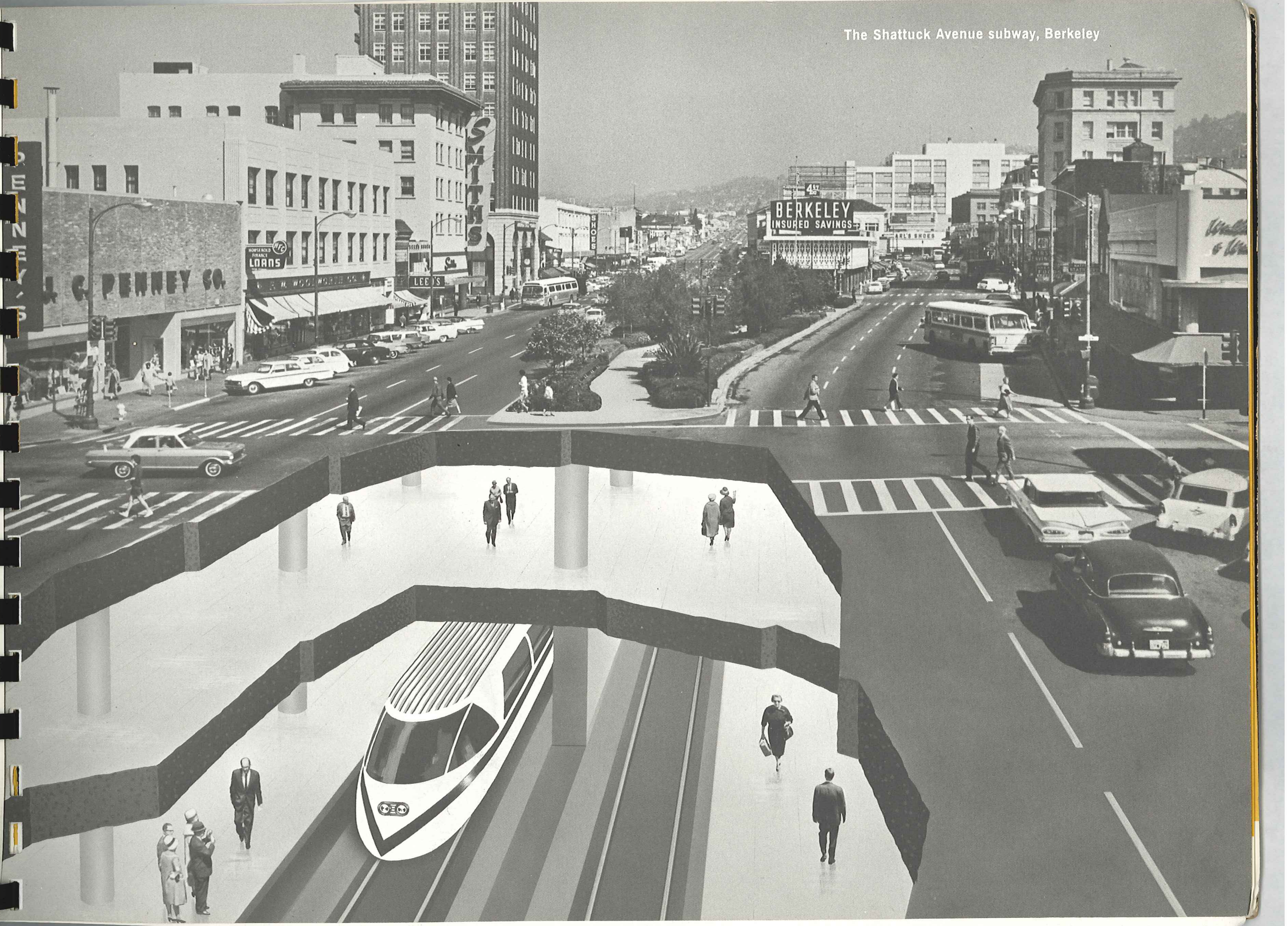
The Market Street subway complex, San Francisco

The Broadway subway complex, Oakland

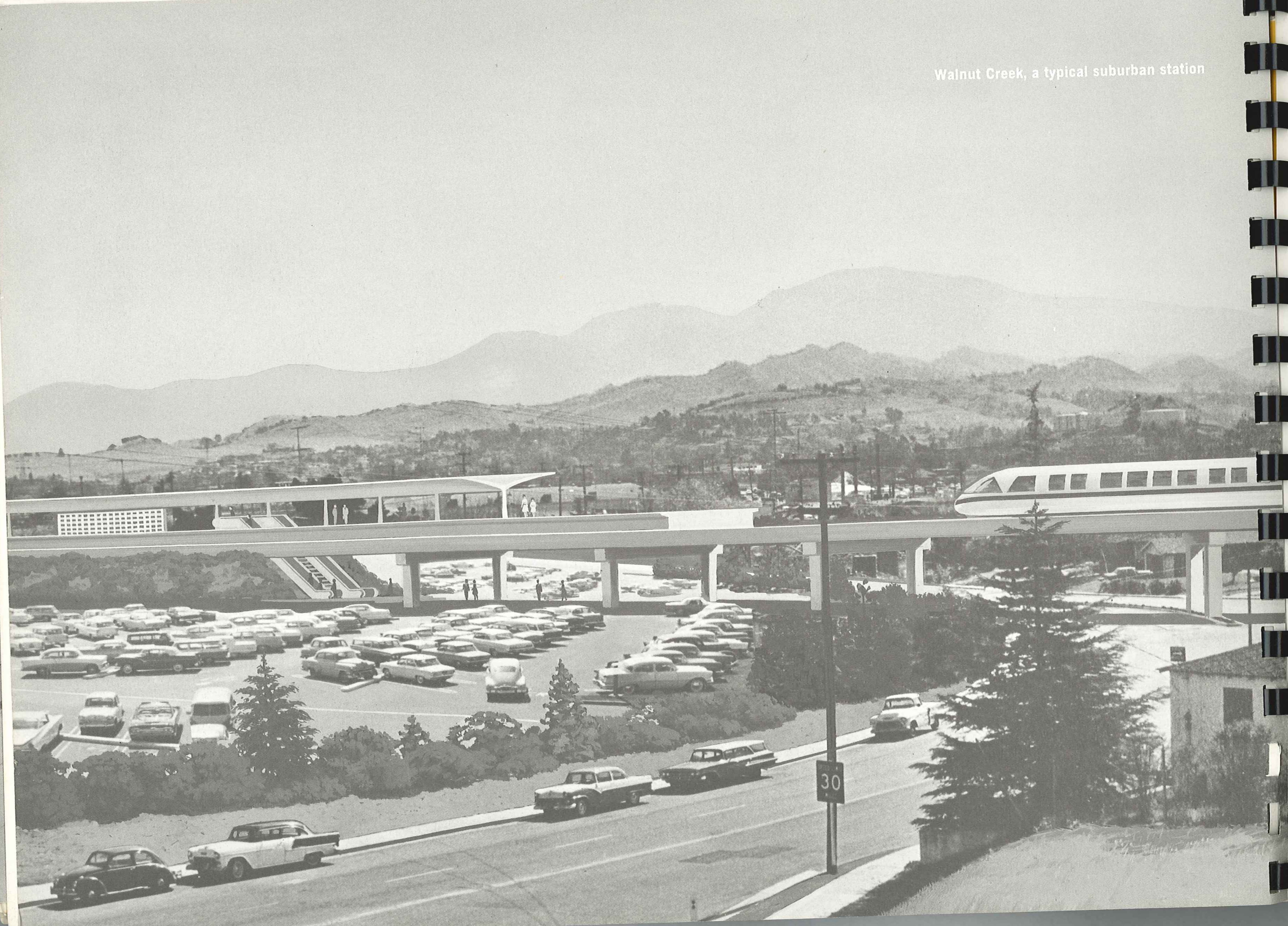




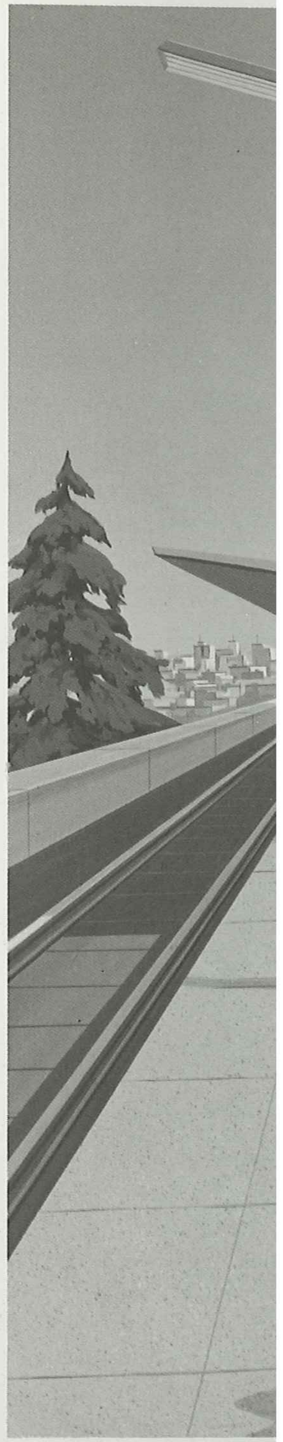
ay complex, Oakland



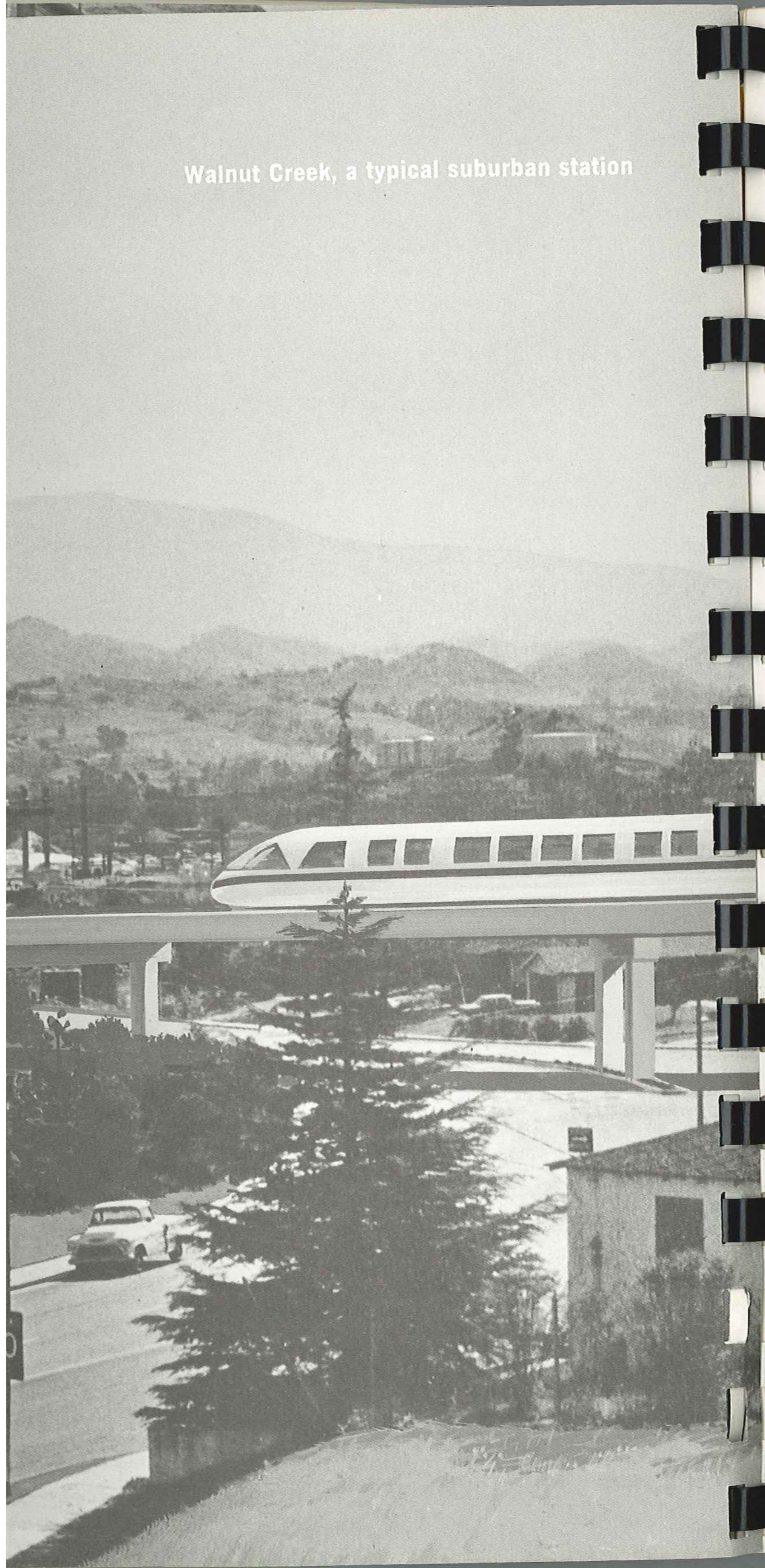
The Shattuck Avenue subway, Berkeley



Walnut Creek, a typical suburban station



The passenger boarding level



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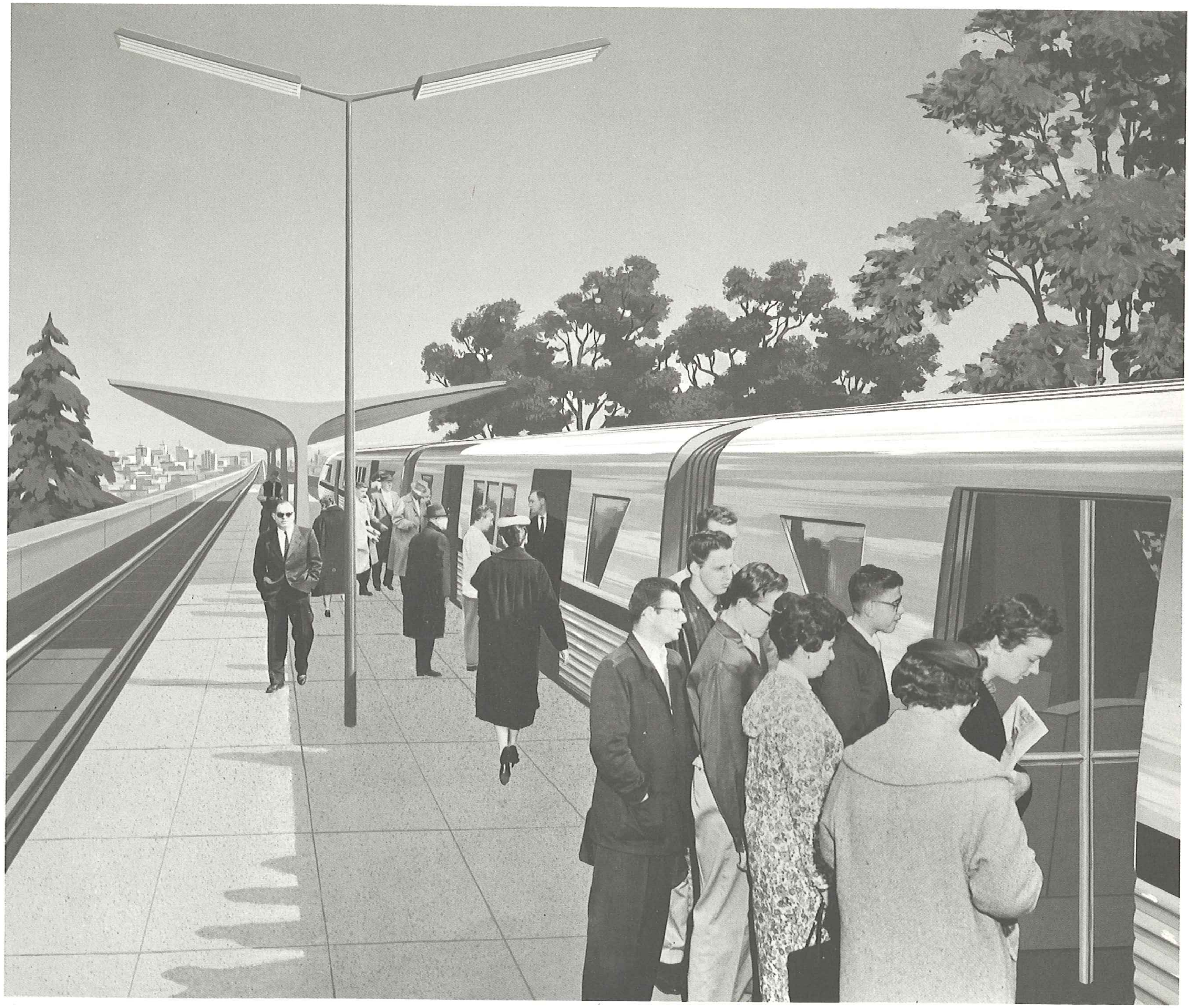

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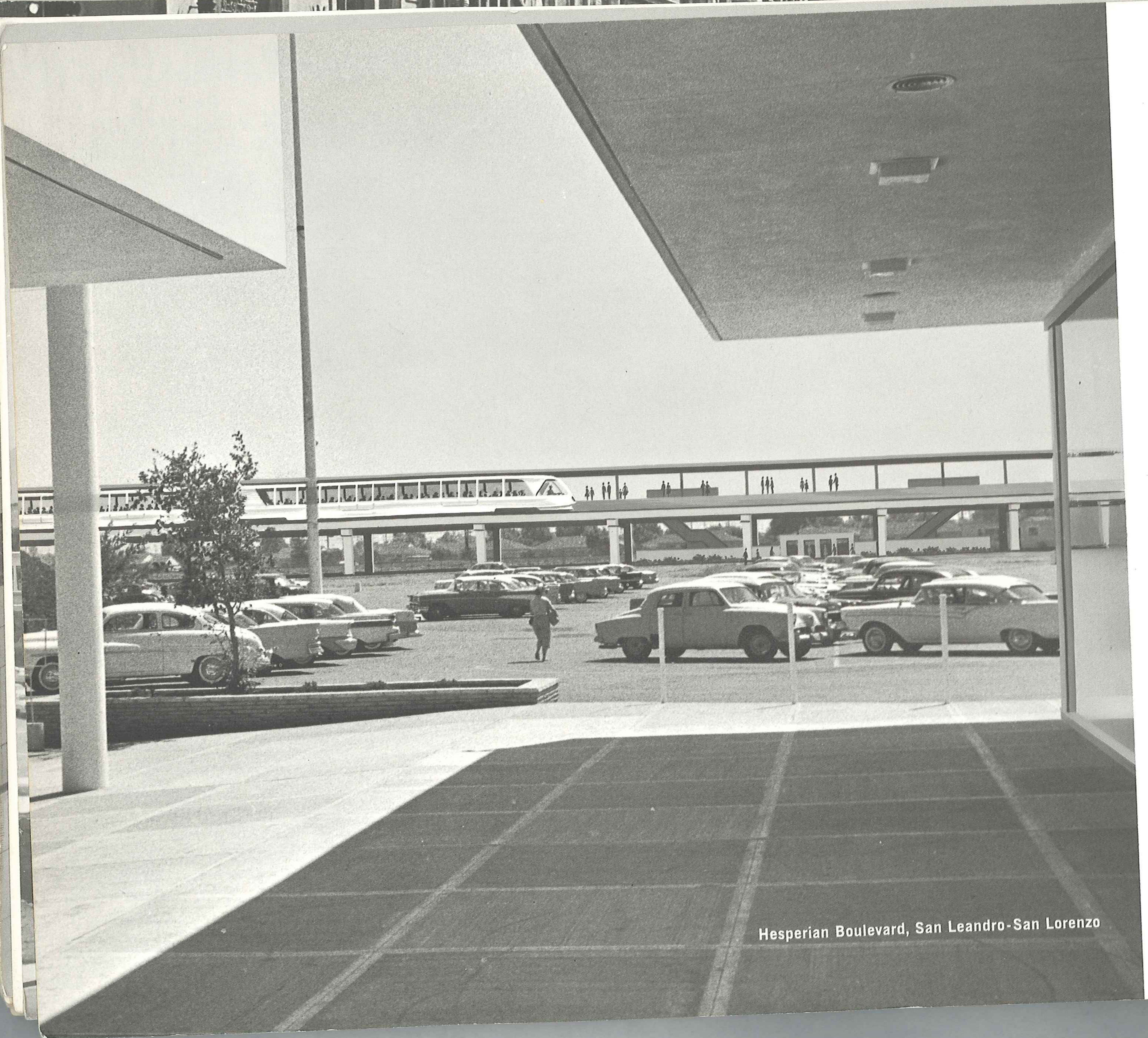
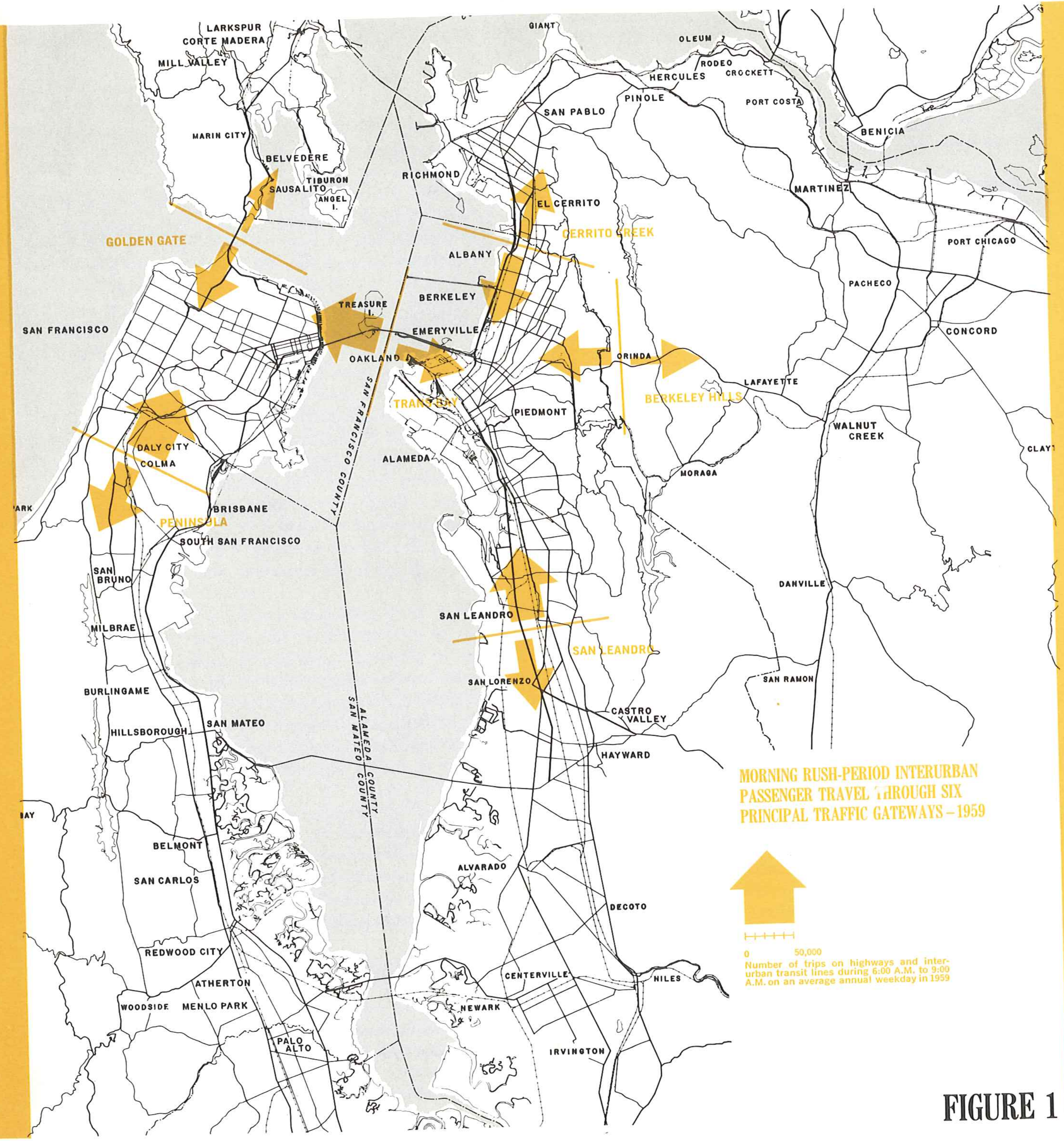


Hesperian Boulevard, San Leandro-San Lorenzo



MORNING RUSH-PERIOD INTERURBAN PASSENGER TRAVEL THROUGH SIX PRINCIPAL TRAFFIC GATEWAYS – 1959

Number of trips on highways and interurban transit lines during 6:00 A.M. to 9:00 A.M. on an average annual weekday in 1959

FIGURE 1

TABLE II

Interurban Passenger Travel Through Six Bay Area Gateways, 6 to 9 a.m. and 4 to 7 p.m. on an Average Day

	1954	*1959*	*Per Cent Change*
Person Trips via Public Transit	83,992	71,140	–15%
Person Trips via Private Automobile	266,854	381,105	+43%
Total Person Trips	350,846	452,245	+29%
Total Private Automobiles	154,251	221,573	+44%
Average Number Persons per Private Vehicle	1.73	1.72	No Change

SOURCE: Parsons Brinckerhoff-Tudor-Bechtel

Moreover, the population aged 16 years and over in the five central counties grew only 14 per cent while the number of automobile registrations rose 47 per cent. Thus, the upsurge of automobile registrations was 3.3 times as great as the increase in population in the driving ages. Even San Francisco, which lost 35,000 population, gained 27,000 automobiles, for an increase of 11.4 per cent.

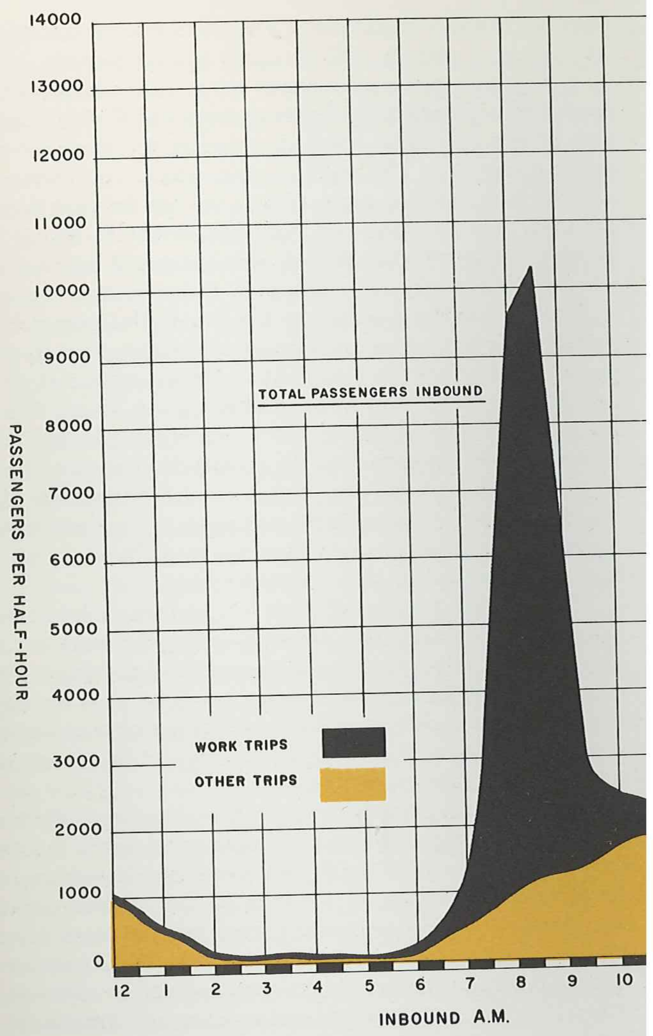
With the future rise of the income level and a sharper increase in residents of driving age, the number of automobiles and local travel therein should continue to increase much faster than the whole population in the Bay Area. In 1960 the nine Bay Area counties had 1,488,000 registered automobiles, and in 1980 they are expected to have 2,930,000 – approximately twice as many as in 1960.

DECLINE OF TRANSIT TRAVEL

The area's transportation problem has been further intensified by the decline of inter-county travel on existing mass transit. Between 1954 and 1959, interurban transit trips through the major Bay Area traffic gateways declined 15 per cent at rush hours, contributing materially to the 44 per cent rise in automobile traffic (Table II).

TOPOGRAPHY AND INTERURBAN TRANSPORTATION

Transportation among the Bay Area's communities is handicapped by the separations imposed by its topography. San Francisco Bay and San Pablo Bay split the region into three



PEAK HOUR VOLUMES OF PASSEN

(ACCOR

PREPARED FOR SAN FRANCISCO BAY AREA RAPID

FIGURE 2

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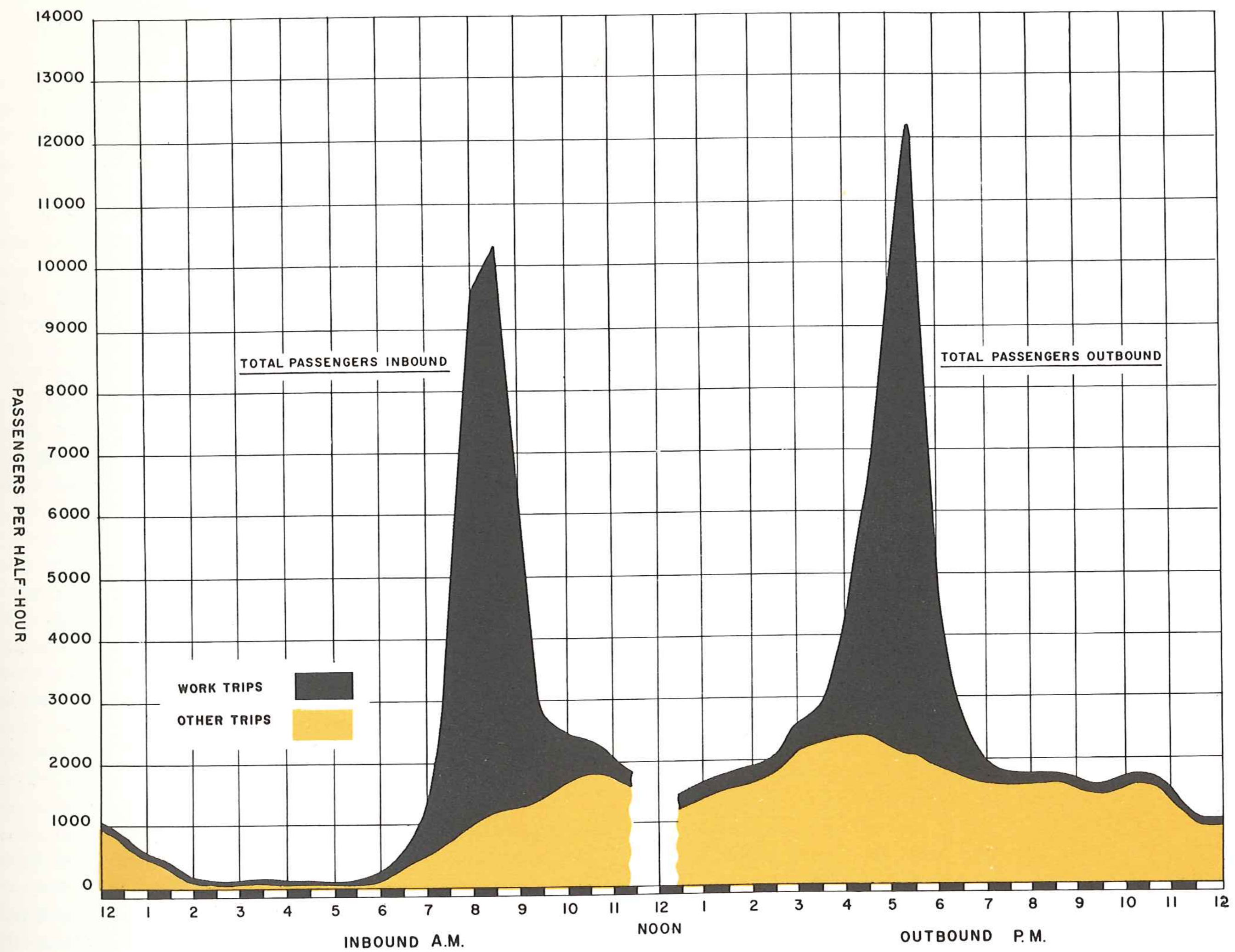
TOPOGRAPHY AND INTERURBAN TRANSPORTATION

Transportation among the Bay Area's communities is handicapped by the separations imposed by its topography. San Francisco Bay and San Pablo Bay split the region into three parts – East Bay, West Bay, and North Bay. Moreover, the ring of hills rimming the Bay forces inter-community traffic through narrow gorges or tunnels. Thus, the area's physical configurations have created transportation bottlenecks at entrances to San Francisco, Oakland and Berkeley.



PEAK HOUR VOLUMES OF PASSENGERS AT SAN FRANCISCO - PENINSULA GATEWAY

(ACCORDING TO PURPOSE OF TRIP)

PREPARED FOR SAN FRANCISCO BAY AREA RAPID TRANSIT COMMISSION BY PARSONS, BRINCKERHOFF, HALL & MACDONALD SAN FRANCISCO NEW YORK

FIGURE 2

The most serious traffic congestion in the Bay Area now occurs mainly in two categories. One is blockage and stalling on arterial highways at the gateways to the central cities, and other freeway bottlenecks. The other is the overcrowding of vehicles in downtown business districts. These two types of congestion are closely related: the more automobiles that pour into the downtown districts from the suburbs, the greater the vehicular over-crowding.

THE PEAK-HOUR PROBLEM

The millions of daily trips in the Bay Area are of various lengths and for a variety of purposes. These trips are grouped generally, however, as "local" or "interurban"; "work" or "other"; and "rush-hour" or "non rush-hour" trips. While rapid transit, directly or indirectly, will substantially improve the conditions of travel for all types of trips, its primary role is to carry most efficiently the high volumes of passenger traffic which are compressed into the morning and evening rush hours along the main travel arteries connecting residential areas with the employment centers and subcenters.

This traffic funnels mainly through six major interurban traffic gateways, illustrated in Figure 1, on page 78, along narrow corridors formed by bridges, tunnels, mountains and waterfronts. The volume of interurban travel through these gateways, averaging more than 10 miles per trip, begins to rise sharply about one hour before the peak traffic flow is reached, and then declines for another hour before leveling out. As shown in Figure 2 on this page, the day-time traffic volumes along these routes are as much as ten times higher at the peak of traffic than at the mid-day low. Thus, within a two to three hour period each morning and evening, the demand upon transportation facilities is great. During these two rush periods, more than one-half of all interurban daily travel takes place; and interurban transportation facilities must be designed to accommodate it. The peak-hour problem is essentially a mass transportation problem.

HIGHWAY DEFICIENCIES

Extensive studies were conducted by the District's engineers to determine future regional traffic flows. Traffic volumes were projected from the expected future land-use pattern and concentrations of population, business and industry. The projections of population and travel in the five central coun-